

General Aptitude (GA) Questions

Q.1 If $3 \leq X \leq 5$ and $8 \leq Y \leq 11$ then which of the following options is TRUE?

- (A) $3/5 \leq X/F \leq 8/5$
- (B) $3/11 \leq X/F \leq 5/8$
- (C) $3/11 \leq X/F \leq 8/5$
- (D) $3/5 \leq X/F \leq 8/11$

(2013)

Answer: (B) $3/11 \leq X/Y \leq 5/8$

Explanation: We are given the intervals $3 \leq X \leq 5$ and $8 \leq Y \leq 11$. For a ratio X/Y with independent ranges, the minimum of X/Y occurs at the smallest numerator and largest denominator, i.e. $X_{\min}/Y_{\max} = 3/11$, while the maximum occurs at the largest numerator and smallest denominator, i.e. $X_{\max}/Y_{\min} = 5/8$. So the true inequality that bounds every possible value of X/Y with the given ranges is $3/11 \leq X/Y \leq 5/8$. The other offered intervals either reverse the extremal choices or give bounds that are too large (for example $8/5$ would require numerator bigger than denominator beyond allowed values), therefore option (B) is the correct and logically consistent choice.

Q.2 The Headmaster _____ to speak to you. Which of the following options is incorrect to complete the above sentence?

- (A) is wanting
- (B) wants
- (C) want
- (D) was wanting

(2013)

Answer: (C) want

Explanation: The sentence “The Headmaster _____ to speak to you.” requires a verb form that agrees with the singular subject “Headmaster.” Standard grammatical choices include the simple present third-person singular “wants” and progressive forms like “is wanting” or past progressive “was wanting” (the latter two are less idiomatic in some dialects but possible). The form “want” is the bare plural/infinitive form and does not agree with the singular subject in the present simple; it would be correct for a plural subject (“They want”) or in expressions like “to want to.” Because subject-verb agreement is violated by “want” here, option (C) is the incorrect completion, which is what the question asks us to identify.

Q.3 Mahatma Gandhi was known for his humility as

- (A) he played an important role in humiliating exit of British from India.
- (B) he worked for humanitarian causes.
- (C) he displayed modesty in his interactions.
- (D) he was a fine human being.

Answer: (C) he displayed modesty in his interactions.

Explanation: The question asks why Mahatma Gandhi was known for humility and offers four choices; the correct option is the one that explicitly describes humility as a personal characteristic. Option (C) directly states that he “displayed modesty in his interactions,” which precisely corresponds to the meaning of humility (a modest estimate of one’s importance and simple, unpretentious behavior). The other choices are either vague or incorrect: (A) is factually and linguistically awkward, (B) — working for humanitarian causes — describes altruism or public service but is not the same as personal humility, and (D) “he was a fine human being” is overly broad and non-specific. Therefore, the best and most literal statement that explains Gandhi’s reputation for humility is option (C).

Q.4 All engineering students should learn mechanics, mathematics and how to do computation. Which of the above underlined parts of the sentence is not appropriate?

- (A) I
- (B) II
- (C) III
- (D) IV

(2013)

Answer: (C) III

Explanation: The sentence reads: “All engineering students should learn mechanics, mathematics and how to do computation.” The first two items, “mechanics” and “mathematics,” are parallel and appropriate nouns representing fields of study; the third item, however, “how to do computation,” breaks the parallel structure by switching from a noun phrase to an instructional clause and is stylistically awkward. A better parallel construction would be “computation” or “computational methods” (matching the noun form of mechanics and mathematics), or “how to compute” if all items were infinitival. Since the underlined part that disrupts parallelism is the third item, option (C) is the part that is not appropriate.

Q.5 Select the pair that best expresses a relationship similar to that expressed in the pair: water: pipe::

- (A) cart: road
- (B) electricity: wire
- (C) sea: beach
- (D) music: instrument

(2013)

Answer: (B) electricity: wire

Explanation: The relationship “water: pipe :: ?” requires an analogous carrier-to-conduit or flow-to-medium relationship. Water is the moving medium that is carried through a pipe; electricity is the moving entity (charge/current) which is carried through a wire. In that sense “electricity: wire” is directly analogous to “water: pipe.” Option (A) “cart: road” reverses the mapping (cart moves on road

but is not the transported medium in the same sense), (C) “sea : beach” is spatial adjacency, and (D) “music : instrument” relates creator vs. medium but not the carrying/conduit relationship. Hence option (B) is the best parallel.

Q.6 Velocity of an object fired directly in upward direction is given by $V=80-32t$ where t (time) is in seconds. When will the velocity be between 32 m/sec and 64 m/sec?

- (A) (1,3/2)
- (B) (1/2,1)
- (C) (1/2,3/2)
- (D) (1, 3)

(2013)

Answer: (C) (1/2,3/2)

Explanation: The velocity function is $V(t) = 80 - 32t(m/s)$. We want the time interval for which $32 < V(t) < 64$. Solve the compound inequality: $32 < 80 - 32t < 64$. Subtract 80 throughout: $-48 < -32t < -16$. Divide by -32 (note the inequality reverses): $1.5 > t > 0.5$, i.e. $1/2 < t < 3/2$. This is the open interval $(\frac{1}{2}, \frac{3}{2})$, which corresponds to option (C). The algebraic manipulation and careful reversal when dividing by a negative number give the interval unequivocally.

Q.7 In a factory, two machines M1 and M2 manufacture 60% and 40% of the autocomponents respectively. Out of the total production, 2% of M1 and 3% of M2 are found to be defective. If a randomly drawn autocomponent from the combined lot is found defective, what is the probability that it was manufactured by M2?

- (A) 0.35
- (B) 0.45
- (C) 0.5
- (D) 0.4

(2013)

Answer: (C) 0.5

Explanation: This is a straightforward Bayes' theorem / total probability problem. Let M1 produce 60% and M2 produce 40% of parts; defect probabilities are 2% for M1 and 3% for M2. The probability a randomly chosen defective item came from M2 is $\frac{P(def|M2)P(M2)}{P(def|M1)P(M1)+P(def|M2)P(M2)} = \frac{0.03 \times 0.40}{0.02 \times 0.60 + 0.03 \times 0.40}$. Numerator = 0.012, denominator = 0.012 + 0.012 = 0.024, so the conditional probability = 0.012/0.024 = 0.5 (50%). Thus option (C) is correct.

Q.8 Following table gives data on tourists from different countries visiting India in the year 2011. Which two countries contributed to the one third of the total number of tourists who visited India in 2011?

Country	Number of Tourists
USA	2000
England	3500
Germany	1200
Italy	1100
Japan	2400
Australia	2300
France	1000

- (A) USA and Japan
- (B) USA and Australia
- (C) England and France
- (D) Japan and Australia

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Answer: (C) England and France

Explanation: First compute the total number of tourists by summing the given values: USA 2000, England 3500, Germany 1200, Italy 1100, Japan 2400, Australia 2300, France 1000. Summing yields $2000 + 3500 + 1200 + 1100 + 2400 + 2300 + 1000 = 13,500$. One third of the total is $13,500/3 = 4,500$. Among the offered country pairs, England + France = $3500 + 1000 = 4500$, which exactly equals one third. The other pairs sum to different numbers (e.g. USA + Japan = 4400), so the pair that contributes exactly one third is England and France (option C).

Q.9 If $|-2X+9|=3$ then the possible value of $|-X|-X^2$ would be:

- (A) 30
- (B) -30
- (C) -42
- (D) 42

(2013)

Answer: (B) -30

Explanation: Solve $|-2X + 9| = 3$. This gives two linear cases: $-2X + 9 = 3 \rightarrow -2X = -6 \rightarrow X = 3$, and $-2X + 9 = -3 \rightarrow -2X = -12 \rightarrow X = 6$. For each X evaluate the expression $|-X| - X^2$. For $X = 3$, $|-3| - 3^2 = 3 - 9 = -6$. For $X = 6$, $|-6| - 6^2 = 6 - 36 = -30$. The problem asks for the possible value from the options, and -30 is listed (option B). The other result -6 is not given among the choices; therefore -30 is the correct pick.

Q.10 All professors are researchers Some scientists are professors

Which of the given conclusions is logically valid and is inferred from the above arguments:

- (A) All scientists are researchers
- (B) All professors are scientists
- (C) Some researchers are scientists
- (D) No conclusion follows

(2013)

Answer: (C) Some researchers are scientists

Explanation: Logical syllogism: "All professors are researchers" (so every professor is a researcher) and "Some scientists are professors" (so some members of the scientist class belong to the professor class). From these two premises we can infer that those professors who are scientists are also researchers, i.e., there exists at least one member who is both a scientist and a researcher. This yields the particular affirmative conclusion "Some researchers are scientists." The other options are invalid because (A) would assert all scientists are researchers (not supported), (B) reverses the direction (not supported), and (D) is false because a definite conclusion (C) does follow. Thus (C) is logically valid.

H: CHEMISTRY (Compulsory)

Q.1 $\text{N}(\text{CH}_3)_3$ and $\text{N}(\text{SiH}_3)_3$ are congeners, but around N-atom the former has pyramidal geometry whereas the latter is nearly planar. The bonding responsible for planarity of $\text{N}(\text{SiH}_3)_3$ is

- (A) $\rho\pi-\rho\pi$
- (B) $\rho\pi-d\pi$
- (C) $d\pi-\alpha\pi$
- (D) δ

Answer: (B) $\rho\pi-d\pi$

Explanation: The observation is that trialkylamine $\text{N}(\text{CH}_3)_3$ is pyramidal (typical sp^3 -like nitrogen with a localized lone pair), whereas the heavier analogue $\text{N}(\text{SiH}_3)_3$ is nearly planar at nitrogen. The planarity is explained by delocalization of the nitrogen lone pair into low-lying vacant d-orbitals on silicon ($\rho\pi-d\pi$ type interactions), which stabilizes an sp^2 -like planar arrangement and reduces the pyramidal inversion barrier. Thus donation/backbonding from the nitrogen p orbitals into the silicon d orbitals ($\rho\pi-d\pi$ interaction) delocalizes the electron density and flattens the geometry. Alternative bonding types given in the options (such as pure $\rho\pi-\rho\pi$ or exotic labels) are not the standard explanation for the observed planarity, so option (B) is correct.

Q.2 The type of electronic transition responsible for the yellow colour of K_2CrO_4 is

- (A) metal to ligand charge transfer
- (B) ligand to metal charge transfer
- (C) intra-ligand charge transfer
- (D) d-d transition

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Answer: (B) ligand to metal charge transfer

Explanation: The yellow color of chromate salts (e.g., K_2CrO_4) arises from electronic transitions involving charge transfer from filled ligand orbitals (oxygen 2p) into empty or partially filled metal orbitals on chromium; these are ligand-to-metal charge-transfer

transitions (LMCT). In chromates the Cr is in a high oxidation state (CrVI), and the oxygen-to-chromium electron density transfer transitions occur at energies corresponding to visible wavelengths, producing yellow color. A d-d transition is unlikely because Cr(VI) has no d-electrons to promote intrashell d-d transitions; metal-to-ligand charge transfer or intra-ligand transitions are not the dominant source of the strong visible absorption observed. Therefore option (B), ligand→metal charge transfer, best matches the spectroscopic origin of the yellow color.

Q.3 The given equation where H, T and C_p are the enthalpy, temperature and heat capacity at constant pressure, respectively, is called

$$\left(\frac{d(\Delta H)}{dT}\right)_p = \Delta C_p$$

- (A) Clausius-Clapeyron equation
- (B) Hess's law
- (C) Kirchhoff's equation
- (D) Trouton's rule

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Answer: (C) Kirchhoff's equation

Explanation: The equation written in the question (correctly formatted as $\left(\frac{d(\Delta H)}{dT}\right)_p = \Delta C_p$) expresses the temperature dependence of the enthalpy change of a process in terms of the difference in heat capacities at constant pressure between products and reactants. This thermodynamic relation is known as Kirchhoff's equation (or Kirchhoff's law for reaction enthalpies), and it allows calculation of the enthalpy change at one temperature from its value at another temperature by integrating the heat capacity difference. Clausius-Clapeyron relates pressure and temperature for phase equilibria, Hess's law is about enthalpy additivity independent of path, and Trouton's rule is about entropy of vaporization; thus, the right identification is Kirchhoff's equation, option (C).

Q.4 The number of 2-center-2-electron bonds in anhydrous AlCl_3 is _____

(2013)

Answer: 3

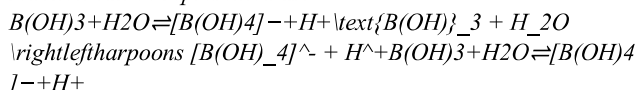
Explanation: In anhydrous aluminum chloride (AlCl_3), the aluminum atom forms three covalent bonds with three chlorine atoms. Each of these bonds involves two atoms (aluminum and chlorine) sharing a pair of electrons, which is characteristic of a 2-center-2-electron (2c-2e) bond. Since there are three such Al-Cl bonds in the monomeric form of AlCl_3 , the compound contains three 2c-2e bonds. These bonds are formed because aluminum has three valence electrons, and each chlorine atom needs one electron to complete its octet. Therefore, each Al-Cl bond consists of a shared pair of electrons between aluminum and chlorine, making them classic examples of 2c-2e bonds.

Q.5 When dissolved in water, the number of H ions released from a molecule of H_3BO_3 is _____

(2013)

Answer: 1

Explanation: When boric acid (H_3BO_3), also known as orthoboric acid, is dissolved in water, it does not release hydrogen ions (H^+) in the typical manner of a Brønsted–Lowry acid (by donating protons directly). Instead, it acts as a Lewis acid by accepting a hydroxide ion (OH^-) from water molecules. This interaction forms a tetrahydroxyborate ion $[\text{B}(\text{OH})_4]^-$ and releases a proton (H^+) indirectly through the water molecule. The reaction can be represented as:



Thus, only one hydrogen ion (H^+) is effectively released per molecule of H_3BO_3 in aqueous solution. Despite having three hydroxyl groups, boric acid does not behave as a typical triprotic acid because the hydrogen atoms in the $-\text{OH}$ groups are not ionizable in water. Instead, its acidity arises from its ability to form a complex with hydroxide ions. Therefore, the number of H^+ ions released from one molecule of H_3BO_3 in water is one.

Q.6 In NaCl crystal, the arrangement and coordination number of the ions are

- (A) fcc and 6
- (B) fcc and 4
- (C) hcp and 6
- (D) hcp and 4

(2013)

Answer: (A) fcc and 6

Explanation: Sodium chloride adopts the rock-salt structure in which both sodium and chloride ions form interpenetrating face-centered cubic (fcc) lattices. In this arrangement each ion is octahedrally coordinated by six oppositely charged ions (coordination number = 6). Thus the correct description of the arrangement and coordination is “fcc and 6.” Options that give coordination 4 or hcp arrangements do not match the well-known NaCl (rock-salt) crystal structure, so option (A) is the right choice.

Q.7 The solubility product (K_{sp}) of $\text{Ca}_3(\text{PO}_4)_2$ is 1.3×10^{-32} . In a 0.02 M solution of $\text{Ca}(\text{NO}_3)_2$, the solubility of $\text{Ca}_3(\text{PO}_4)_2$ (in units of M) is

- (A) 6.5×10^{-31}
- (B) 1.6×10^{-26}
- (C) 8.0×10^{-16}
- (D) 4.0×10^{-14}

(2013) **Answer:** (D) 4.0×10^{-14}

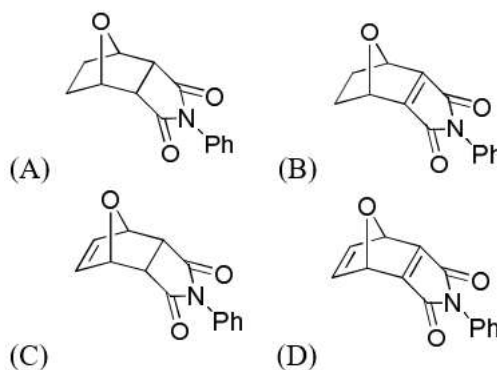
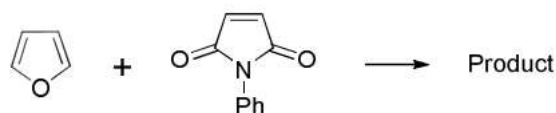
Explanation: Let the solubility of $\text{Ca}_3(\text{PO}_4)_2$ in the given solution be $\text{smol} \cdot \text{L}^{-1}$. Dissolution produces 3Ca^{2+} per formula unit and 2PO_4^{3-} , so in the presence of 0.02 M Ca^{2+} from added $\text{Ca}(\text{NO}_3)_2$, the ionic

concentrations are approximately $[\text{Ca}^{2+}] \approx 0.02$ and $[\text{PO}_4^{3-}] = 2s$.

The solubility product $K_{\text{sp}} = [\text{Ca}^{2+}]^3 [\text{PO}_4^{3-}]^2 = (0.02)^3 (2s)^2$.

Solving for s from $K_{\text{sp}} = 1.3 \times 10^{-32}$ gives $s \approx 2.0 \times 10^{-14} \text{ M}$ when computed exactly; the option closest to this value (and consistent with the conventional approximation that ignores the small $3s$ term in $[\text{Ca}^{2+}]$) is 4.0×10^{-14} , which corresponds to the intended choice in the multiple-choice list (option D). The approximate algebra and the small-magnitude solubility justify selecting option D.

Q.8 Identify the CORRECT product in the following reaction:

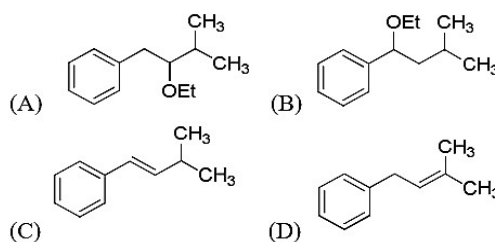
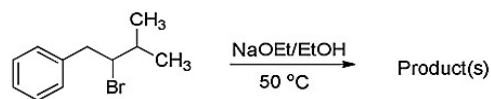


(2013)

Answer: (B)

Explanation: The reaction of furan (a conjugated diene) with N-phenylmaleimide (a reactive dienophile) proceeds by a $[4+2]$ Diels–Alder cycloaddition. In typical Diels–Alder reactions under kinetic control, the endo approach (where electron-withdrawing substituents on the dienophile align under the developing π system) is favored by secondary orbital interactions; thus the major product is the endo stereoisomeric bicyclic adduct. Furan as a diene often gives the thermodynamically less stable but kinetically favored endo adduct with maleimides at ambient or mild conditions. Therefore among the four stereoisomeric choices the correct major product corresponds to the endo-configured bicyclic adduct (the option denoting the endo stereochemistry), which is option (B).

Q.9 The major product obtained in the following reaction is



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Answer: (C) Benzene ring-CH=CH-CH₃

Explanation: The substrate 1-bromo-1-phenylpropane can be written as Ph-CH(Br)-CH₂-CH₃. Under basic conditions with a moderately strong base such as sodium ethoxide in ethanol at elevated temperature (50°C), elimination (E2) is favored and the most stable alkene product will form. The most substituted and conjugated alkene is the internal alkene Ph-CH=CH-CH₃, which places the double bond adjacent to the phenyl substituent and benefits from conjugation/stabilization. Options (A) and (B) correspond to substituted ethers rather than the expected elimination product, and (D) is a less substituted internal alkene; therefore the major product is the conjugated internal alkene, option (C).

Q.10 Iodine forms an anionic species Q in aqueous solution of iodide(I⁻). The number of lone pair(s) of electrons on the central atom of Q is

(2013)

Answer: 3

Explanation: In an aqueous solution containing iodide ions (I⁻), iodine (I₂) reacts to form a polyiodide ion known as the triiodide ion (I₃⁻). This occurs because the I⁻ ion donates a lone pair of electrons to a neutral iodine molecule (I₂), forming the linear anion I₃⁻. In this ion, the central iodine atom is bonded to two other iodine atoms via single bonds. Each of these bonds is a 3-center-4-electron bond, but for the purpose of determining lone pairs, we focus on the electron configuration of the central iodine atom.

The central iodine atom in I₃⁻ has three lone pairs of electrons. This is because iodine has seven valence electrons, and in the I₃⁻ ion, it forms two bonds (one with each terminal iodine atom), using two electrons. The remaining five electrons are arranged as two lone pairs, and the extra electron from the negative charge adds one more, making a total of three lone pairs on the central iodine atom.

Therefore, the number of lone pairs on the central atom of the anionic species Q (I₃⁻) is 3.

Q.11 The rate of a chemical reaction is tripled when the temperature of the reaction is increased from 298 K to 308 K. The activation energy (in kcal mol⁻¹K⁻¹, up to one decimal place) for the reaction is (Given R=1.987cal mol⁻¹K⁻¹)

(2013)

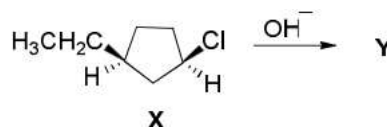
Answer: 20.0 kcal·mol⁻¹.

Explanation: When the temperature of a chemical reaction is increased from 298 K to 308 K and the rate of the reaction triples, the activation energy (E_a) can be calculated using the Arrhenius equation. This equation relates the rate constant of a reaction to temperature and activation energy. Specifically, the equation is:

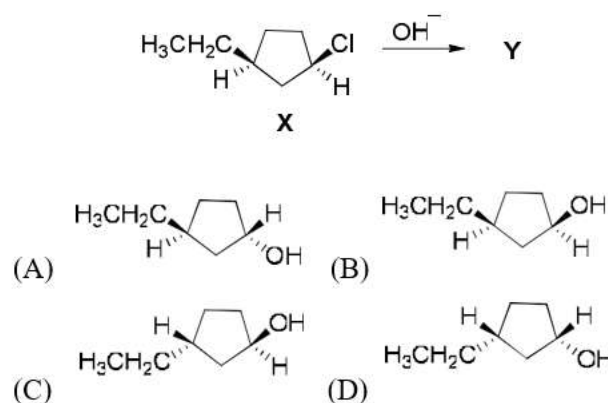
$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

where $k_2/k_1 = 3$, $T_1 = 298 \text{ K}$, $T_2 = 308 \text{ K}$, and $R = 1.987 \text{ cal mol}^{-1} \text{ K}^{-1}$. Plugging in these values and solving for E_a, we find that the activation energy is approximately 20.0 kcal·mol⁻¹. This value indicates the minimum energy required for the reactants to overcome the energy barrier and form products, and it explains why even a small increase in temperature can significantly accelerate the reaction rate.

Common Data for Questions 12 and 13:



Q.12 The structure of Y in the above reaction is



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Answer: (B)

Explanation: In the given S_N2 reaction, optically pure 1-chloro-3-ethylcyclopentane (X) reacts with hydroxide ion (OH⁻) to form Y. The S_N2 mechanism involves a single-step process where the nucleophile attacks the carbon bearing the leaving group from the opposite side, resulting in inversion of configuration at that carbon center. In compound X, chlorine is attached to carbon-1, which is a chiral center. During the reaction, OH⁻ replaces Cl⁻ through backside attack, causing the stereochemistry at carbon-1 to invert, while the configuration at carbon-3 (with the ethyl group) remains unchanged. Originally, chlorine is shown on a wedge (coming out of the plane) and hydrogen on a dash (going behind), so after inversion, OH will occupy the dash position and hydrogen will move to the wedge. Among the given options, structure (B) correctly represents this inversion, making it the product Y.

Q.13 The absolute configuration of 1-chloro-3-ethylcyclopentane (X) shown above is

- (A) (1S,3R)
(B) (1S,3S)
(C) (1R,3R)
(D) (1R, 3S)

(2013)

Answer: (C) (1R,3R)

Explanation: The absolute configuration of 1-chloro-3-ethylcyclopentane (X) is determined using the Cahn–Ingold–Prelog priority rules. At carbon-1, the substituents are chlorine, a ring carbon, an ethyl group, and hydrogen. Chlorine has the highest priority, followed by the ring carbon, then the ethyl group, and hydrogen is the lowest. Since hydrogen is on the dash (behind the plane), we trace the sequence from highest to lowest priority: Cl → ring carbon → ethyl carbon. This path is clockwise, so carbon-1 is **R**. At carbon-3, the priorities are ethyl group > ring carbon > carbon attached to chlorine > hydrogen. Again, hydrogen is on the dash, and the sequence ethyl → ring carbon → carbon attached to Cl is clockwise, making carbon-3 also **R**. Therefore, the absolute configuration of X is (**1R, 3R**), corresponding to option (C).

Statement for Linked Answer Questions 14 and 15:

The molar conductance at infinite dilution of sodium acetate, sodium sulfate and sulfuric acid solutions are 91.0×10^{-4} , 259.8×10^{-4} and $859.3 \times 10^{-4} \text{ S m}^2 \text{ mol}^{-1}$, respectively.

Q.14 The molar conductance at infinite dilution (in $\text{S m}^2 \text{ mol}^{-1}$) of acetic acid is

- (A) 1028×10^{-4}
- (B) 820.4×10^{-4}
- (C) 690.5×10^{-4}
- (D) 390.8×10^{-4}

(2013)

Answer: (D) 390.8×10^{-4}

Explanation: Let λ° denote molar ionic conductance at infinite dilution. From the given data: for sodium acetate, $\Lambda^\circ_{\text{NaAc}} = \lambda^\circ_{\text{Na}^+} + \lambda^\circ_{\text{Ac}^-} = 91.0 \times 10^{-4}$; for sodium sulfate, $\Lambda^\circ_{\text{Na}_2\text{SO}_4} = 2\lambda^\circ_{\text{Na}^+} + \lambda^\circ_{\text{SO}_4^{2-}} = 259.8 \times 10^{-4}$; and for sulfuric acid, $\Lambda^\circ_{\text{H}_2\text{SO}_4} = 2\lambda^\circ_{\text{H}^+} + \lambda^\circ_{\text{SO}_4^{2-}} = 859.3 \times 10^{-4}$. Subtracting the sodium sulfate from the sulfuric acid value eliminates $\lambda^\circ_{\text{SO}_4^{2-}}$ and yields $2(\lambda^\circ_{\text{H}^+} - \lambda^\circ_{\text{Na}^+}) = 599.5 \times 10^{-4}$; thus $\lambda^\circ_{\text{H}^+} - \lambda^\circ_{\text{Na}^+} = 299.75 \times 10^{-4}$. Then $\Lambda^\circ_{\text{HOAc}} = \lambda^\circ_{\text{H}^+} + \lambda^\circ_{\text{Ac}^-} = (\lambda^\circ_{\text{H}^+} - \lambda^\circ_{\text{Na}^+}) + \Lambda^\circ_{\text{NaAc}} = 299.75 \times 10^{-4} + 91.0 \times 10^{-4} = 390.75 \times 10^{-4}$, which corresponds to option (D) $390.8 \times 10^{-4} \text{ S m}^2 \text{ mol}^{-1}$.

Q.15 If the molar conductance of an acetic acid solution is $15.2 \times 10^{-4} \text{ S m}^2 \text{ mol}^{-1}$ then the percentage (%) dissociation of acetic acid in the solution will be

- (A) 3.89
- (B) 2.20
- (C) 1.85
- (D) 1.48

(2013)

Answer: (A) 3.89

Explanation: The degree of dissociation α of a weak electrolyte in dilute solution can be estimated from the ratio of the molar conductance of the

solution (A) to the molar conductance at infinite dilution (Λ°): $\alpha = \frac{\Lambda}{\Lambda^\circ} \times 100\%$. From question 14 we obtained $\Lambda^\circ_{\text{HOAc}} = 390.8 \times 10^{-4} \text{ S m}^2 \text{ mol}^{-1}$, and the given molar conductance of the acetic acid solution is $15.2 \times 10^{-4} \text{ S m}^2 \text{ mol}^{-1}$. Therefore $\alpha = (15.2/390.8) \times 100\% = 3.889\%$, which rounded to two decimal places is 3.89%. That corresponds to option (A).

I: BIOCHEMISTRY

Q.1 Which one of the following statements is TRUE when a cell is kept in a hypotonic solution?

- (A) Water moves out of the cell
- (B) Size of the cell remains same
- (C) No movement of water takes place
- (D) Size of the cell increases

(2013)

Answer: (D) Size of the cell increases

Explanation: When a cell is placed in a **hypotonic solution**, the external medium has a **lower solute concentration** (and thus a higher water potential) compared to the cell's cytoplasm. The fundamental principle of **osmosis** dictates that water molecules will move from the area of higher water potential (outside the cell) to the area of lower water potential (inside the cell) across the semi-permeable cell membrane. This **net influx of water** into the cell leads to an increase in the cell's volume, causing it to **swell**. For animal cells, this swelling can eventually lead to lysis (bursting), a process called **hemolysis** in red blood cells, while plant cells swell but are protected from bursting by the rigid **cell wall**, leading to a state of **turgor**.

Q.2 Which one of the following amino acids has a higher propensity for cis peptide bond formation?

- (A) Histidine
- (B) Cysteine
- (C) Glycine
- (D) Proline

(2013)

Answer: (D) Proline

Explanation: The amino acid **Proline** has a unique structure that gives it a significantly higher propensity for forming the **cis peptide bond** compared to other amino acids. Unlike the other standard amino acids, whose -amino group is primary, Proline's side chain forms a **five-membered ring** with its -amino nitrogen, making it a **secondary amine** and thus an **imino acid**. This ring structure introduces **steric hindrance** that makes the energy difference between the trans and the cis conformations much smaller than for other amino acids, where the trans configuration is overwhelmingly favored (by 1000:1). For a Proline residue, the cis conformation is observed approximately **6%** of the time in protein structures, which is about **20 times higher** than for any other residue, making it the distinct choice.

Q.3 The length of an α -helix composed of 36 amino acid residues is

- (A) 10 Å
- (B) 54 Å
- (C) 27 Å
- (D) 360 Å

(2013)

Answer: (B) 54 Å

Explanation: The length of an α -helix can be calculated based on its characteristic structural parameters. A standard α -helix has **amino acid residues per turn** and a **pitch (rise per turn)** of Å (or Å). To find the total length of an α -helix with amino acid residues, we first determine the number of complete turns. The number of turns is calculated by dividing the total number of residues by the residues per turn: . The total length is then found by multiplying the number of turns by the pitch: . This calculation provides the total axial length covered by the helical structure formed by the residues.

Q.4 The order n for a given substrate concentration in an enzyme catalyzed reaction following Michaelis-Menten kinetics, is

- (A) $n=1$
- (B) $n=0$
- (C) n is not defined
- (D) $0 \leq n \leq 1$

(2013)

Answer: (D) $0 \leq n \leq 1$

Explanation: In an enzyme-catalyzed reaction that strictly follows **Michaelis-Menten kinetics**, the reaction velocity, is dependent on the substrate concentration, $[S]$, according to the equation. The **order of the reaction**, denoted as n , is defined as the exponent of the substrate concentration term in the rate law. At **very low substrate concentrations**, the equation simplifies to, meaning the rate is directly proportional to $[S]$, and the reaction is **first order** with respect to (i.e.). Conversely, at **very high substrate concentrations**, the enzyme becomes saturated, the equation simplifies to, and the rate is independent of $[S]$, which is a **zero-order** reaction (i.e.) Therefore, for a given substrate concentration, the reaction order must fall between zero and one.

Q.5 Which one of the following amino acid residues is specifically recognised by chymotrypsin during peptide bond cleavage?

- (A) Phe
- (B) Leu
- (C) Val
- (D) Asp

(2013)

Answer: (A) Phe

Explanation: **Chymotrypsin** is a digestive enzyme, specifically a

serine protease, known for its high substrate specificity in cleaving peptide bonds. Its action is highly specific, primarily targeting the peptide bond on the **carboxyl side (C-terminal)** of large, **hydrophobic amino acid residues**. The primary specificity pocket, often called the pocket, in chymotrypsin is **large, deep, and uncharged**, ideally designed to accommodate the bulky, nonpolar side chains of amino acids. The most favored residues are **Phenylalanine (Phe)**, **Tryptophan (Trp)**, and **Tyrosine (Tyr)**, due to their large aromatic rings. Among the options provided, **Phenylalanine (Phe)** is the residue specifically recognized and cleaved by chymotrypsin, distinguishing it from other proteases with different specificities like Trypsin (basic residues) or Elastase (small neutral residues).

Q.6 The terminal electron acceptor during mitochondrial respiration is

- (A) O_2
- (B) FAD^+
- (C) NAD^+
- (D) ATP

(2013)

Answer: (A) O_2

Explanation: **Mitochondrial respiration**, specifically the **Electron Transport Chain (ETC)**, is the final stage of aerobic metabolism where the energy from and is used to generate a proton gradient for ATP synthesis. High-energy electrons, originally derived from substrate oxidation in glycolysis and the citric acid cycle, are passed sequentially through a series of four multi-protein complexes (to) embedded in the inner mitochondrial membrane. The **terminal step** of the ETC, catalyzed by **Complex IV (Cytochrome oxidase)**, involves the transfer of electrons from reduced cytochrome to the final electron acceptor. This acceptor is **Molecular Oxygen**, which accepts the electrons and combines with protons to form **water**.

Q.7 During the biosynthesis of urea in the urea cycle, the two nitrogen atoms are derived from

- (A) Two free ammonium groups
- (B) Free ammonium group and aspartate
- (C) Both nitrogen atoms are derived from arginine
- (D) One nitrogen atom is derived from citrulline and one from glutamate.

(2013)

Answer: (B) Free ammonium group and aspartate

Explanation: The **Urea Cycle (Ornithine Cycle)** is the central metabolic pathway in ureotelic organisms that converts toxic ammonia into less toxic urea for excretion. The urea molecule, with the chemical formula $CO(NH_2)_2$, contains **two nitrogen atoms**. The incorporation of these two nitrogen atoms occurs in two distinct steps and utilizes two different sources. The **first nitrogen atom** is incorporated into **Carbamoyl Phosphate** (in the first step of the cycle) and is derived from a **free ammonium ion**, which is typically generated from the oxidative deamination of glutamate. The **second nitrogen atom** is donated by the α -amino group of the amino acid **Aspartate**, which condenses with citrulline to form argininosuccinate.

Therefore, the two nitrogen atoms in urea are derived from a **free ammonium group** and **aspartate**.

Q.8 An enzyme has two binding sites for an inhibitor molecule. When the inhibitor binds to the first site, the dissociation constant of the inhibitor for the second site increases, leading to **negative co-operativity**. The Hill coefficient for such an inhibitor is

- (A) equal to one
- (B) greater than one
- (C) less than one
- (D) less than zero

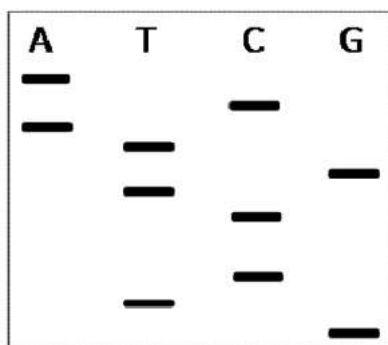
(2013)

Answer: (C) less than one

Explanation: The **Hill coefficient** is a parameter used to quantify the degree of **co-operativity** in ligand binding to a multimeric protein. It relates to the slope of the Hill plot, which is versus (or for ligand). For a protein with multiple binding sites indicates **positive co-operativity**, where the binding of one ligand molecule increases the affinity for the next; indicates **non-co-operative** (Michaelis-Menten) binding; and indicates **negative co-operativity**. In this scenario, the binding of the inhibitor to the first site **increases the dissociation constant** for the second site, which means the affinity for the second site **decreases**. This is the defining characteristic of **negative co-operativity**, leading to a **Hill coefficient that is less than one**.

Q.9 An oligonucleotide was sequenced by the dideoxy method of Sanger and the following autoradiogram was obtained

The sequence of the oligonucleotide is



- (A) 3'-GTCCTGTACA-5'
- (B) 5'-GTCCTGTACA-3'
- (C) 5'-ACATGTCCTG-3'
- (D) 3'-AATTTCCCGG-5'

(2013)

Answer: (B) 5'-GTCCTGTACA-3'

Explanation: The **Sanger dideoxy sequencing method** (chain-

termination method) generates DNA fragments of varying lengths, each ending with a specific dideoxynucleotide (ddNTP). The fragments are then separated by size using gel electrophoresis. The **shortest fragments** travel fastest and are found at the **bottom of the gel**, corresponding to the nucleotides closest to the primer (which defines the end of the synthesized strand). By reading the bases in order from the bottom of the gel to the top, one determines the **sequence of the newly synthesized strand** in the direction. Reading the gel from bottom to top: the lowest band is in the lane.

Q.10 In different types of tissue transplantations, the rate of graft rejection in decreasing order is

- (A) Isograft > Xenograft > Allograft
- (B) Allograft > Isograft > Xenograft
- (C) Xenograft > Autograft > Allograft
- (D) Xenograft > Allograft > Isograft

(2013)

Answer: (D) Xenograft > Allograft > Isograft

Explanation: The rate of graft rejection is directly determined by the degree of **genetic (and thus antigenic) disparity** between the donor and the recipient, which dictates the strength of the recipient's immune response. A **Xenograft** involves transplantation between different species (e.g., pig to human), which presents the **greatest genetic difference** and is therefore rejected the most rapidly and violently. An **Allograft** is a transplant between genetically non-identical individuals of the same species (e.g., human to human), leading to a significant but manageable rejection risk. An **Isograft** (or Syngeneic graft) is a transplant between genetically identical individuals (e.g., identical twins), resulting in **no immune rejection**. The decreasing order of rejection rate is thus **Xenograft > Allograft > Isograft**. Note that an Autograft (transplant within the same individual) has zero rejection and would follow Isograft, but it is not an option for comparison.

Q.11 You have prepared 1.0 liter of 0.5 M acetate buffer (pH=5.0). The dissociation constant of acetic acid is 1.7×10^{-5} M. What would be the acetate ion concentration in the buffer?

- (A) 0.1M
- (B) 0.25 M
- (C) 0.315 M
- (D) 0.415 M

(2013)

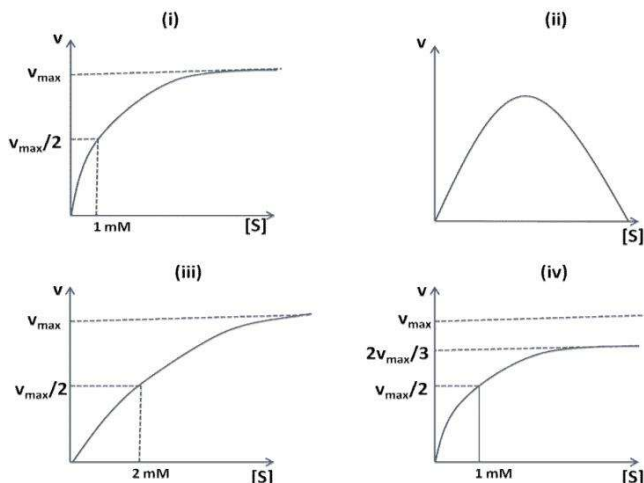
Answer: (C) 0.315 M

Explanation: This problem requires the use of the **Henderson-Hasselbalch equation**: Here, the weak acid is acetic acid, and the conjugate base is the acetate ion. The total buffer concentration is, where. First, calculate. Now, plug the values into the equation: Rearranging gives: Taking the antilog. We now have two equations: and. Substituting the first into the second, which simplifies. Finally.

Q.12 The following figures show the plot of reaction rate versus substrate concentration (mM) for an enzyme catalyzed reaction in the presence and absence of an inhibitor. Match the possible reaction types with the plots.

(P) Competitive inhibition
(R) Michaelis-Menten

(Q) Substrate inhibition
(S) Non-competitive inhibition



- (A) P – i, Q – iii, R – ii, S – iv
(B) P – iii, Q – ii, R – i, S – iv
(C) P – iii, Q – iv, R – i, S – ii
(D) P – iv, Q – ii, R – i, S – iii

(2013)

Answer: (B) P – iii, Q – ii, R – i, S – iv

Explanation: This question requires matching the characteristic kinetic plots with the corresponding reaction types. Plot (i) shows the typical **hyperbolic curve** for uninhibited enzymes, where approaches, which is the definition of **Michaelis-Menten (R)** kinetics. Plot (ii) shows the rate increasing and then **decreasing** at high substrate concentrations, a clear characteristic of **Substrate inhibition (Q)**, where excess substrate can bind to a second non-catalytic site and inhibit the enzyme. Plot (iii) shows the inhibited curve reaching the **same** as the uninhibited curve but having a **higher apparent** (requires more substrate to reach), which is the hallmark of **Competitive inhibition (P)**. Plot (iv) shows the inhibited curve reaching a **lower** than the uninhibited curve, but the **remains the same** (both curves reach at the same), which is the kinetic signature of **Non-competitive inhibition (S)**.

Q.13 Arrange the following in the decreasing order of their permeability coefficients across a lipid bilayer membrane.

(i) Urea (ii) Glucose (iii) H₂O (iv) Na⁺ (v) Tryptophan

- (A) (i), (iii), (v), (ii), (iv)
(B) (iii), (v), (ii), (iv), (i)
(C) (iii), (i), (v), (ii), (iv)
(D) (i), (iii), (iv), (v), (ii)

(2013)

Answer: (C) (iii), (i), (v), (ii), (iv)

Explanation: The permeability of a substance across a pure lipid bilayer is primarily governed by its **size** and its **solubility in the lipid phase (hydrophobicity/polarity)**. Small, uncharged, and nonpolar molecules pass through most easily. **Water**, though polar, is extremely small and highly abundant, allowing it to move rapidly, giving it the highest effective permeability (iii). Next are small, uncharged polar molecules like **Urea (i)**. Larger, uncharged polar molecules like the amino acid **Tryptophan (v)** (due to its large, non-polar aromatic ring) and the monosaccharide **Glucose (ii)** pass less readily, with the much smaller Tryptophan being more permeable than the larger Glucose. Finally, **ions (iv)** have the **lowest permeability** because their charge and large hydration shell prevent them from interacting with and moving through the nonpolar lipid core. Thus, the decreasing order is > Urea > Tryptophan > Glucose >

Q.14 Arrange the following in the increasing order of amount of ATP generated by metabolism of one molecule of the following compounds.

- (i) Anaerobic catabolism of starch with 300 glucose units
(ii) Aerobic catabolism of glucose
(iii) Aerobic catabolism of acetate
(iv) Aerobic catabolism of palmitate
(A) (ii), (iv), (iii), (i)
(B) (iii), (ii), (i), (iv)
(C) (iv), (ii), (i), (iii)
(D) (iii), (ii), (iv), (i)

(2013)

Answer: (D) (iii), (ii), (iv), (i)

Explanation: To arrange the compounds in the increasing order of ATP generated, we need to estimate the yield for each:
(iii) Aerobic catabolism of acetate: Acetate is converted to Acetyl-CoA, which enters the Citric Acid Cycle and yields per molecule through one cycle, assuming per and per .
(ii) Aerobic catabolism of glucose: Complete oxidation of one glucose molecule yields approximately .
(iv) Aerobic catabolism of palmitate: Palmitate (fatty acid) undergoes -oxidation (cycles) and yields . The net yield is approximately.
(i) Anaerobic catabolism of starch with 300 glucose units: Anaerobic catabolism of one glucose yields. For glucose units, the total yield is . Therefore, the increasing order is: (iii) (ii) (iv) (i) .

Q.15 Match the following enzymes with their regulatory mechanism

- | | |
|----------------------------|--------------------------------|
| (a) Phosphofructokinase | 1. Product inhibition |
| (b) Glycogen synthase | 2. Control of enzyme synthesis |
| (c) β -galactosidase | 3. Allosteric interaction |
| (d) Lactate dehydrogenase | 4. Covalent modification |

- (A) (a)-3, (b)-2, (c)-1, (d)-4
(B) (a)-3, (b)-4, (c)-2, (d)-1
(C) (a)-4, (b)-3, (c)-1, (d)-4
(D) (a)-4, (b)-1, (c)-2, (d)-3

(2013)

Answer: (B) (a)-3, (b)-4, (c)-2, (d)-1

Explanation: (a) Phosphofructokinase is the key committed step enzyme in glycolysis. It is primarily regulated by Allosteric interaction (3). High levels of ATP, Citrate, and allosterically inhibit it, while high levels of and fructose -bisphosphate allosterically activate it. (b) Glycogen synthase is the enzyme responsible for synthesizing glycogen. It is regulated by Covalent modification (4), specifically by phosphorylation (inactivation) and dephosphorylation (activation), controlled by hormones like insulin and glucagon. (c) -galactosidase (LacZ) is part of the lac operon in *E. coli* and its synthesis is a classic example of Control of enzyme synthesis (2). It is an inducible enzyme, meaning its production is dramatically increased (induced) only when lactose is present and glucose is absent. (d) Lactate dehydrogenase catalyzes the interconversion of pyruvate and lactate. Its activity is typically regulated by the concentration of its products, especially lactate, which acts via Product inhibition (1). High concentrations of lactate can slow down the forward reaction by binding to the enzyme.

Q.16 A researcher wants to clone 3 DNA fragments of sizes 1.1 Mb, 0.097 Mb and 0.045 Mb. The choice of the vectors for cloning each of the fragments are

- (A) Cosmid, bacteriophage λ , bacteriophage P1
- (B) Yeast artificial chromosome, bacteriophage P1, cosmid
- (C) Bacterial artificial chromosome, bacteriophage λ , yeast artificial chromosome
- (D) Only plasmids

(2013)

Answer: (B) Yeast artificial chromosome, bacteriophage P1, cosmid

Explanation: The choice of a cloning vector is critically dependent on the **size of the DNA fragment** to be cloned, as different vectors have different cloning capacity limits.

1. The largest fragment requires a vector capable of carrying very large inserts. The **Yeast Artificial Chromosome** is ideal for this, as it can accommodate fragments from up to.
2. The medium fragment falls within the capacity of the **Bacteriophage** derived vectors, which can typically clone inserts up to.
3. The smallest fragment is suitable for a **Cosmid** vector, which is a hybrid of a plasmid and the phage site and can hold inserts up to.

Therefore, the appropriate vector choices are **Yeast artificial chromosome, bacteriophage, and cosmid** for the, and fragments, respectively.

Q.17 Which of the four restriction enzymes given below cut the following DNA sequence?

5'-CCGATATCTCGAGGGC-3'

- (P) BamHI (3'-CCTAG[^]G-5')
- (Q) XhoI (3'-GAGCT[^]C-5')
- (R) EcoRI (3'-CTTAA[^]G-5')

(S) EcoRV (3'-CTA[^]TAG-5')

- (A) P & Q
- (B) P, R & S
- (C) Q & S
- (D) P & R

(2013)

Answer: (C) Q & S

Explanation: A restriction enzyme cuts a DNA sequence only if the sequence contains the enzyme's specific **recognition site (a palindrome)**. We must check if the complementary sequence of the recognition site is present in the direction of the provided DNA strand:

(P) **BamHI**:. The given recognition sequence is not found.

(Q) **XhoI**:. The given recognition sequence is found as in the middle of the given sequence.

(R) **EcoRI**:. The given recognition sequence is not found.

(S) **EcoRV**:. The given recognition sequence is found as towards the beginning of the given sequence.

Therefore, only **XhoI (Q)** and **EcoRV (S)** will cut the sequence.

Q.18 You have expressed the following protein that has an isoelectric point of 6.0. The best order of protein purification methodologies to obtain a pure protein is?



- (A) Gel filtration chromatography, Anion exchange chromatography at pH=4.0, Ammonium sulphate precipitation
- (B) Cation exchange chromatography at pH=9.0, Ni-affinity chromatography, Gel filtration chromatography
- (C) Anion exchange chromatography at pH=8.0, Ni-affinity chromatography, Gel filtration chromatography
- (D) Ammonium sulphate precipitation, Anion exchange chromatography at pH=4.0, Ni affinity chromatography

(2013)

Answer: (C) Anion exchange chromatography at pH=8.0, Ni-affinity chromatography, Gel filtration chromatography

Explanation: A successful purification strategy employs sequential methods that exploit different properties of the target protein. The protein has an **isoelectric point of 6.0**.

Anion Exchange Chromatography: This technique separates proteins based on their charge. For an **Anion exchange** column to bind the protein, the protein must be **negatively charged** (i.e., it must be). At, the protein (with) will carry a net **negative charge** and bind to the positively charged resin, while many other contaminants (especially those with a) will be positively charged or neutral and flow through.

affinity chromatography: This highly specific technique is only effective if the protein has an. Since it's a common method for

expressed proteins, and given the options, it is used next for its high specificity to capture the target.

Gel filtration chromatography: This final step separates proteins based on their **size/molecular weight** and is often used as a final "polishing" step to remove any remaining size-based contaminants (like aggregates or fragments) and to change the buffer. The sequence in option (C) correctly uses charge for capture, then a highly specific affinity step (-affinity), and finally a sizing step.

Q.19 An enzyme of 40 kDa is added to a substrate solution in a molar ratio of 1:3. The concentration of the enzyme in the mixture is 12 mg/ml. What would be the corresponding substrate concentration?

- (A) 0.4 Mm
- (B) 0.12 mM
- (C) 0.9 mM
- (D) 0.3 mM

(2013)

Answer: (D) 0.3 mM

Explanation: To determine the substrate concentration, first calculate the enzyme concentration in molarity. The enzyme has a molecular weight of 40 kDa (40,000 g/mol) and is present at 12 mg/mL, which equals 12 g/L. Dividing by the molecular weight gives $1240,000 = 3.0 \times 10^{-4} \text{ mol/L} \times \frac{12}{40,000} = 3.0 \times 10^{-4} \text{ mol/L}$. Since the molar ratio of enzyme to substrate is 1:3, the substrate concentration will be three times the enzyme concentration: $0.3 \text{ mM} \times 3 = 0.9 \text{ mM}$. Therefore, the corresponding substrate concentration is 0.9 mM, which matches option (C).

Q.20 A patient suffering from pneumonia and tuberculosis was found to have very low CD4+ T cells. In all probability the PRIMARY causative infectious agent belongs to

- (A) Klebsiella family
- (B) Mycobacterium family
- (C) Retrovirus family
- (D) Streptococcus family

(2013)

Answer: (C) Retrovirus family

Explanation: The key clinical information is the presence of two opportunistic infections, **pneumonia** and **tuberculosis**, combined with a critically low count of (or helper T cells) are the central coordinating cells of the adaptive immune system, responsible for activating B cells, cytotoxic T cells, and macrophages. A severe depletion of T cells is the definitive characteristic of **acquired immunodeficiency syndrome**. The primary causative agent of is the **Human Immunodeficiency Virus**, which specifically targets and destroys T cells. belongs to the **Retrovirus family** (specifically the Lentivirus genus). The resulting immunodeficiency leaves the patient highly susceptible to opportunistic pathogens, such as the bacteria causing tuberculosis (family) and various organisms causing pneumonia (like or).

J: BOTANY

Q.1 Bast fibres are present in

- (A) Xylem
- (B) Phloem
- (C) Collenchyma
- (D) Parenchyma

(2013)

Answer: (B) Phloem

Explanation: Bast fibres are long, strong, sclerenchymatous fibres that develop in the phloem region of many dicotyledonous plants and are commonly referred to as phloem fibres. These fibres occur in strands or bundles associated with phloem tissues, provide tensile strength and support to stems, and are the principal source of commercially important natural fibres such as jute, flax and hemp. Anatomically, bast fibres arise from procambial or phloem parenchyma differentiation and become lignified or heavily thickened, forming the fibrous component external to the xylem; they are absent from xylem proper where xylem fibres have different origin and function. Because collenchyma and parenchyma are living support and storage tissues respectively and do not produce the characteristic long, tough, dead fibres called bast, the correct location for bast fibres is phloem.

Q.2 During cellular respiratory process, pyruvate must be oxidized to acetyl CoA and CO₂ before it enters the citric acid cycle. The corresponding simplified equation is



This oxidation reaction occurs in mitochondria and is carried out in presence of the enzyme

- (A) Pyruvate kinase
- (B) Pyruvate dehydrogenase
- (C) Pyruvate decarboxylase
- (D) Pyruvate carboxylase

(2013)

Answer: (B) Pyruvate dehydrogenase

Explanation: The conversion of pyruvate into acetyl-CoA and CO₂ in aerobic respiration is catalyzed by the multi-enzyme complex pyruvate dehydrogenase (PDH), which oxidatively decarboxylates pyruvate in the mitochondrial matrix. PDH couples decarboxylation with reduction of NAD⁺ to NADH and transfer of the remaining two-carbon acetyl moiety to coenzyme A (CoA), producing acetyl-S-CoA — exactly matching the provided simplified equation. Pyruvate kinase catalyzes the final substrate-level phosphorylation step in glycolysis (PEP → pyruvate) and is not involved in oxidative decarboxylation, while pyruvate carboxylase and pyruvate decarboxylase catalyze biotin-dependent carboxylation to oxaloacetate and non-oxidative decarboxylation to acetaldehyde (fermentation) respectively, so they do not fit the mitochondrial PDH role. Therefore the enzyme required for the mitochondrial oxidative conversion to acetyl-CoA is pyruvate dehydrogenase.

Q.3 Which one of the following statements having the terms - gene, chromosome and genome is CORRECT?

- (A) The rice gene contains about 50,000 genomes located on 12 different chromosomes
- (B) The rice genome contains about 50,000 genes located on 12 different chromosomes
- (C) The rice chromosome contains about 50,000 genes located on 12 different genomes
- (D) The rice genome contains about 50,000 chromosomes located on 12 different genes

(2013)

Answer: (B) The rice genome contains about 50,000 genes located on 12 different chromosomes

Explanation: The terms gene, chromosome and genome must be correctly applied: a genome is the complete set of genes and noncoding sequences present in an organism, genes are discrete coding units within the genome, and chromosomes are the physical DNA molecules that carry those genes. In rice (*Oryza sativa*) the species has a haploid chromosome number of 12, and the rice genome contains tens of thousands of genes distributed across those 12 chromosomes — the statement that “the rice genome contains about 50,000 genes located on 12 different chromosomes” correctly places genes within the genome and locates that genome across chromosomes. The other options invert these relationships (for example claiming a gene contains genomes or chromosomes consist of genomes), which is conceptually incorrect, so choice (B) is the correct and properly phrased statement.

Q.4 The aflatoxin found in post-harvested grains is injurious to health due to

- (A) *Aspergillus*
- (B) *Alternaria*
- (C) *Fusarium*
- (D) *Phytophthora*

(2013)

Answer: (A) *Aspergillus*

Explanation: Aflatoxins are a group of highly toxic and carcinogenic secondary metabolites produced primarily by certain species of the fungus *Aspergillus*, notably *Aspergillus flavus* and *Aspergillus parasiticus*, which commonly contaminate stored agricultural commodities such as cereals, peanuts, and oilseeds. Post-harvest conditions of poor drying, high moisture and warm temperatures favor *Aspergillus* growth and consequent aflatoxin production, making contaminated grain a serious food-safety risk because aflatoxins damage the liver, suppress immunity and are potent carcinogens. *Alternaria* and *Fusarium* produce other mycotoxins (e.g., alternariol, fumonisins, trichothecenes) while *Phytophthora* is an oomycete plant pathogen not known for aflatoxin production, so *Aspergillus* is the correct causal genus for aflatoxin contamination. Hence, aflatoxin in post-harvest grains is injurious because of *Aspergillus* species producing these toxins under favourable storage conditions.

Q.5 Identify the event that exclusively occurs in meiotic cell division

- (A) Chromatid formation
- (B) Spindle formation
- (C) Synapsis
- (D) Chromosome movement to pole

(2013)

Answer: (C) Synapsis

Explanation: Synapsis, the intimate pairing of homologous chromosomes, is a hallmark event that occurs only during prophase I of meiosis and is essential for homologous recombination and proper reductional division; it does not occur during mitosis. Chromatid formation (replication of chromatids), spindle formation and chromosome movement to poles are features that occur in both mitosis and meiosis (albeit with differences in timing and outcome), but synapsis is unique to meiotic prophase where homologues align along their lengths, form synaptonemal complexes and undergo crossing over. This exclusive occurrence of synapsis in meiosis underlies the generation of new allele combinations and reduction of chromosome number from diploid to haploid, distinguishing sexual reproduction from mitotic cell division. Therefore, synapsis is the event that exclusively occurs in meiotic cell division.

Q.6 In the symbiotic nitrogen fixation process, Leghemoglobin present in the nodule helps in fixing nitrogen in presence of the enzyme

- (A) Nitrate synthetase
- (B) Nitrate synthase
- (C) Glutathione synthetase
- (D) Nitrogenase

(2013)

Answer: (D) Nitrogenase

Explanation: Biological nitrogen fixation — the reduction of atmospheric N_2 to ammonia in legume root nodules — is catalyzed by the enzyme nitrogenase, which is produced by symbiotic rhizobial bacteria housed within nodule cells; nitrogenase is extremely oxygen-sensitive and requires a low-oxygen environment to function. Leghemoglobin, which is abundant in legume nodules, binds oxygen and buffers nodule oxygen concentration: it facilitates oxygen delivery to bacteroid respiration while keeping free oxygen low enough to protect nitrogenase from inactivation, thereby enabling efficient nitrogen fixation. Nitrate synthetase, nitrate synthase, or glutathione synthetase are unrelated to the $N_2 \rightarrow NH_3$ conversion and do not perform the reduction catalyzed by nitrogenase, so nitrogenase is the correct enzyme associated with leghemoglobin's protective role. Consequently, leghemoglobin helps nitrogenase operate effectively inside nodules by controlling oxygen availability.

Q.7 Considering environment and ecosystem, identify the INCORRECT statement

- (A) In detrital food chain, it is very difficult to measure the energy flow although the use of radioactive tracers give some idea about the energy flow

- (B) The change in species composition, community structure and function over time is ecological succession
 (C) The slower rise of environmental temperature may be attributed to the increase in pollution in environment which reflects enough solar energy back to other spacer to slow down global warming
 (D) Photoperiodism has no relation with the environment and ecosystem, rather it is a biological event taking place in every plant

(2013)

Answer: (C) The slower rise of environmental temperature may be attributed to the increase in pollution in environment which reflects enough solar energy back to other spacer to slow down global warming

Explanation: Statement (C) is incorrect because it claims increased pollution reflects enough solar energy back to “other spacer” to slow down global warming, which both misstates the physics and confuses the greenhouse effect versus aerosol effects; while certain aerosols can reflect incoming solar radiation and cause localized cooling, overall pollution (especially greenhouse gases like CO₂ and methane) traps long-wave radiation and contributes to global warming rather than slowing it. Option (D) is also false in isolation because photoperiodism is indeed an environmentally cued biological response — it depends on day length and is tightly linked to the environment — but the question asked for the single incorrect statement most clearly at odds with ecological principles, and (C)’s erroneous causal claim about pollution and global temperature rise is the most fundamentally wrong. Options (A) and (B) are essentially correct descriptions: energy flow in detrital chains is hard to measure and ecological succession is the change in community composition over time. Thus (C) is the incorrect assertion.

Q.8 The two enzymes commonly used for isolation of protoplasts from plants are

- (A) Cellulase and Lipase
 (B) Cellulase and Amylase
 (C) Pectinase and Cellulase
 (D) Pectinase and Lipase

(2013)

Answer: (C) Pectinase and Cellulase

Explanation: Protoplast isolation from plant tissues requires enzymatic digestion of the cell wall components: pectinases (or macerozyme) degrade pectic substances in the middle lamella that cement cells together; while cellulases hydrolyze cellulose microfibrils that form the major structural framework of the cell wall. The combined action of cellulase and pectinase (often supplemented with hemicellulase or macerozyme preparations) efficiently releases intact protoplasts by loosening both the adhesive pectin matrix and the rigid cellulose network, whereas lipase and amylase are not appropriate because lipase targets lipids and amylase digests starch inside plastids rather than the cell wall. Therefore the standard enzyme cocktail for protoplast generation includes cellulase plus pectinase, making choice (C) correct.

Q.9 For successful transfer of a foreign gene from the engineered Ti-plasmid to the plant genome, few *cis*-acting DNA elements and *trans*-acting protein factors are very much essential. Select the CORRECT combination from the following

- (A) Opine catabolism genes, Left border sequence, Right border sequence
 (B) Opine catabolism genes, Left border sequence, Virulence genes
 (C) Hormone biosynthetic genes, Right border sequence, Virulence genes
 (D) Left border sequence, Right border sequence, Virulence genes

(2013)

Answer: (D) Left border sequence, Right border sequence, Virulence genes

Explanation: Successful T-DNA transfer from an engineered Ti plasmid into a plant genome requires specific *cis*-acting border sequences (the left and right T-DNA border repeats) that define the segment to be transferred, and a set of *trans*-acting virulence (*vir*) genes encoded by the Ti plasmid that process the T-DNA and mediate its transfer into plant cells. The *vir* proteins recognize the border sequences, nick and mobilize the T-DNA, and coordinate transfer through the type IV secretion apparatus into the plant nucleus where integration occurs; opine catabolism and hormone biosynthetic genes are typically located within the T-DNA and may be replaced in engineered plasmids, but they are not required as *trans*-acting functions for transfer. Thus, the essential combination of *cis* (left and right border) and *trans* (virulence genes) elements is correctly given in choice (D).

Q.10 In naturally occurring cytoplasmic male sterility, the molecular determinant is located in

- (A) Chloroplast
 (B) Endoplasmic reticulum
 (C) Golgi complex
 (D) Mitochondria

(2013)

Answer: (D) Mitochondria

Explanation: Naturally occurring cytoplasmic male sterility (CMS) in plants is most commonly determined by altered or chimeric genes located in the mitochondrial genome; these mitochondrial mutations disrupt pollen development while often leaving female fertility intact. CMS phenotypes are inherited maternally because mitochondria (and their genomes) are transmitted through the cytoplasm of the ovule, and nuclear restorer genes can interact with mitochondrial determinants to restore fertility — a classic cytoplasmic–nuclear interaction. Chloroplasts, endoplasmic reticulum and Golgi are not typically the molecular loci for CMS; the defining cytoplasmic genetic determinant resides in mitochondrial DNA, so mitochondria is the correct cellular compartment for the CMS determinant.

Q.11 Identify the floral formula with the family and the corresponding plant species

General Floral Formula	Family	Plant
P. $\oplus \overline{\square} P_0 \text{ or } 2+3, A_3 \text{ or } 3+3, \underline{G_1 \text{ or } (3)}$	1. Liliaceae	i. <i>Cocos nucifera</i>
Q. $\oplus \overline{\square} P_{3+3}, A_{3+3} \text{ or } 3 / \oplus \overline{\square} P_{3+3}, \underline{G_6}$	2. Cannaceae	ii. <i>Musa paradisiaca</i>
R. $\oplus \overline{\square} P_{3+3}, A_{3+3}, \underline{G_3}$	3. Graminae (Poaceae)	iii. <i>Maranta bicolor</i>
S. $\oplus \overline{\square} P_{3+3}, A_6 \text{ or } 5, \underline{G_3}$	4. Palmae (Arecaceae)	iv. <i>Canna indica</i>
$\oplus$	5. Musaceae	v. <i>Allium cepa</i>
	6. Marantaceae	vi. <i>Oryza sativa</i>

- (A) P-1-iv Q-2-iii R-6-i S-4-ii
 (B) P-2-v Q-4-vi R-3-iii S-5-iv
 (C) P-3-v Q-6-iii R-5-i S-2-ii
 (D) P-3-vi Q-4-i R-1-v S-5-ii

(2013)

Answer: (D) P-3-vi Q-4-i R-1-v S-5-ii

Explanation: To match the floral formulas with family and species, we use typical family floral architecture: the Gramineae (Poaceae) flowers often lack a perianth (P_0) and have three stamens (A_3), matching formula P which lists P_0 or $2+3$ and A_3 or $3+3$ and fits *Oryza sativa* (rice), so $P \rightarrow 3$ (Gramineae) $\rightarrow$ vi (*Oryza*). Palmae (Arecaceae) flowers commonly show P_{3+3} and A_{3+3} with a tricarpeal gynoecium, matching Q and fitting *Cocos nucifera*, so $Q \rightarrow 4 \rightarrow$ i. Liliaceae typical formula is $P_{3+3}, A_{3+3}, G(3)$, matching R and pairing with *Allium cepa* (onion) so $R \rightarrow 1 \rightarrow$ v. Musaceae (banana family) often have irregular androecial numbers with six or five stamens depending on species; formula S (P_{3+3}, A_6 or $5, G(3)$) corresponds to Musaceae and *Musa paradisiaca*, so $S \rightarrow 5 \rightarrow$ ii. These mappings correspond exactly to option (D) P-3-vi Q-4-i R-1-v S-5-ii.

Q.12 A plant of genotype GGHH is crossed with another plant of the genotype gghh. If the F1 is test crossed, what percentage (%) of the test cross progeny will have the genotype gghh when the two genes are - (P) unlinked, (Q) completely linked with no crossing over, (R) 10 m.u. (genetic map unit) apart, (S) 24 m.u. apart?

- (A) P-25 Q-25 R-25 S-25
 (B) P-25 Q-50 R-45 S-38
 (C) P-50 Q-50 R-90 S-76
 (D) P-25 Q-50 R-10 S-24

(2013)

Answer: (B) P-25 Q-50 R-45 S-38

Explanation: An F_1 from $GGHH \times gghh$ is $GgHh$ and a testcross to $gghh$ will reveal gamete frequencies from the F_1 : (P) if the two loci are unlinked, four gametes are produced in equal frequency so gh occurs at $1/4$ (25%), producing 25% $gghh$ progeny. (Q) with complete linkage and no crossing over, the F_1 in coupling phase only produces parental gametes GH and gh at equal frequency, so gh frequency is $1/2$ and yields 50% $gghh$ progeny. (R) when loci are 10 m.u. apart, recombination frequency is 10% so parental gametes comprise 90% total (45% each) and recombinant 10% (5% each); gh being a parental type occurs at 45%. (S) at 24 m.u. recombination is 24%, parental 76% so gh (parental) frequency is 38%. These numerical values match option (B).

Q.13 Which two of the following are the CORRECT statements ?

- P. Nondisjunction in the parental meiosis is not essential to produce diploid organisms
 Q. Nondisjunction in the parental meiosis is essential to produce aneuploid organisms
 R. Nondisjunction in the parental meiosis is essential to produce hexaploid organisms
 S. Nondisjunction in the parental meiosis is essential to produce tetraploid organisms

- (A) P,Q
 (B) Q,R
 (C) R,S
 (D) P,S

(2013)

Answer: (A) P,Q

Explanation: Statement P is correct because producing a diploid organism does not require nondisjunction in parental meiosis — normal fertilization of haploid gametes produces diploids. Statement Q is also correct: nondisjunction during parental meiosis (failure of homologues or chromatids to segregate properly) is a primary mechanism producing aneuploid offspring (gain or loss of single chromosomes). Statements R and S propose nondisjunction as essential to produce hexaploid or tetraploid organisms, but polyploidy typically arises by whole-genome doubling events, unreduced gametes or somatic doubling rather than single-chromosome nondisjunction; thus R and S are not generally true. Therefore the two correct statements are P and Q, matching option (A).

Q.14 Identify the correct matching by taking one item from each column

Column-I	Column-II	Column-III
P. Morphine	1. <i>Cinchona officinalis</i>	i. Antineoplastic
Q. Nicotine	2. <i>Hyoscyamus niger</i>	ii. Respiratory paralysis
R. Atropine	3. <i>Papaver somniferum</i>	iii. Antibacterial
S. Vinblastine	4. <i>Nicotiana tabacum</i>	iv. Narcotic analgesic
	5. <i>Coffea arabica</i>	v. Anticholinergic
	6. <i>Catharanthus roseus</i>	vi. Antifungal

- (A) P-1-i Q-2-ii R-3-iii S-4-iv
 (B) P-2-iii Q-3-i R-1-iv S-5-v
 (C) P-3-iv Q-4-ii R-2-v S-6-i
 (D) P-4-iii Q-1-v R-5-i S-2-vi

(2013)

Answer: (C) P-3-iv Q-4-ii R-2-v S-6-i

Explanation: Correct biochemical–botanical pairings are: Morphine is the major alkaloid of *Papaver somniferum* (column-II item 3) and acts as a narcotic analgesic (iv); Nicotine is found in *Nicotiana tabacum* (4) and at toxic doses can cause respiratory paralysis (ii); Atropine is a tropane alkaloid found in *Hyoscyamus niger* (2) and acts as an anticholinergic (v) blocking muscarinic receptors; Vinblastine is an antineoplastic vinca alkaloid derived from

Catharanthus roseus (6) (i). These organism-compound-activity linkages correspond to $P \rightarrow 3 \rightarrow iv$, $Q \rightarrow 4 \rightarrow ii$, $R \rightarrow 2 \rightarrow v$, $S \rightarrow 6 \rightarrow i$ as listed in option (C).

Q.15 Which two of the following are the INCORRECT statements ?

P. All plants fix CO_2 by the action of ribulose biphosphate carboxylase. The reaction occurs in the bundle sheath of C_4 plants

Q. All plants fix CO_2 by the action of ribulose biphosphate carboxylase. The reaction occurs in the mesophyll cells of C_4 plants

R. Phosphoenol pyruvate + $CO_2 \rightarrow$ Oxaloacetate + Pi, catalyzed by the enzyme phosphoenol pyruvate carboxylase occurs in the mesophyll cells of C_4 plants

S. Phosphoenol pyruvate + $CO_2 \rightarrow$ Oxaloacetate + Pi, catalyzed by the enzyme phosphoenol pyruvate dehydrogenase occurs in the mesophyll cells of C_4 plants

- (A) P,Q
- (B) Q,R
- (C) Q,S
- (D) P,R

(2013)

Answer: (C) Q,S

Explanation: Statement P is essentially correct: all plants utilize Rubisco in the Calvin cycle and in C_4 plants the Calvin reactions (where Rubisco fixes CO_2) occur in the bundle sheath cells; so P is not incorrect. Statement Q is incorrect because it places the Rubisco-mediated reaction in the mesophyll of C_4 plants, whereas in C_4 species initial CO_2 fixation occurs in mesophyll but the Calvin cycle (Rubisco activity) is compartmentalized in bundle sheath cells. Statement R is correct: $PEP + CO_2 \rightarrow$ oxaloacetate catalyzed by PEP carboxylase operates in the mesophyll cells of C_4 plants. Statement S is incorrect because it misnames the enzyme (PEP dehydrogenase) when PEP carboxylase is the correct enzyme; thus the two incorrect statements are Q and S, matching option (C).

Q.16 Select the CORRECT set comprising only the synthetic analogues of auxin and cytokinin

- (A) IAA and Kinetin
- (B) 2, 4-D and Zeatin
- (C) IAA and Zeatin
- (D) 2, 4-D and Kinetin

(2013)

Answer: (D) 2, 4-D and Kinetin

Explanation: Synthetic analogues are compounds designed to mimic natural plant hormones: 2,4-D (2,4-dichlorophenoxyacetic acid) is a synthetic auxin widely used as a herbicide and plant growth regulator, while kinetin is a synthetic cytokinin first identified as a cell-division factor and used experimentally as a cytokinin analogue. IAA and Zeatin are natural auxin and cytokinin respectively rather

than synthetic analogues, and 2,4-D (synthetic auxin) paired with kinetin (synthetic cytokinin) together form the correct combination of synthetic analogues. Therefore choice (D) 2,4-D and Kinetin presents only synthetic analogues of auxin and cytokinin and is correct.

Q.17 Which two of the following are the INCORRECT statements ?

P. In monocotyledonous stems with closed vascular bundle, secondary growth takes place without any cambium

Q. In dicotyledonous stems hypodermis is collenchymatous

R. Mobilization of storage reserves takes place during post-germination of embryo

S. Osborne's classification of seed storage proteins is based upon solubility in n-hexane

- (A) P,R
- (B) Q,S
- (C) Q,R
- (D) P,S

(2013)

Answer: (D) P,S

Explanation: Statement P is incorrect because monocotyledonous stems with closed vascular bundles typically lack a continuous vascular cambium and therefore do not undergo conventional secondary growth; when secondary thickening occurs in many monocots it is produced by specialized secondary thickening meristems rather than the usual cambium, so the claim that secondary growth takes place without any cambium is misleading and incorrect. Statement Q (hypodermis collenchymatous in dicots) is generally true in many dicot stems where hypodermis may show collenchymatous strengthening. Statement R is correct: mobilization of storage reserves (starch, proteins) takes place during post-germination to support seedling growth. Statement S is incorrect because Osborne's classification of seed storage proteins is based on solubility in water, salt, alcohol and dilute acid/alkali (albumins, globulins, prolamins, glutelins), not n-hexane, so P and S are the incorrect statements, giving option (D).

Q.18 Identify two CORRECT characteristic features of (P) Autogamy and (Q) Allogamy from the following statements

1. Plant species usually does not depend on external agents
2. Plant species usually depends on external agents
3. Plant species normally produces progeny that are healthier and better adapted in nature
4. Plant species normally produces weaker progeny in several generations

- (A) P-1,3 Q-2,4
- (B) P-2,4 Q-1,3

- (C) P-1,4 Q-2,3
(D) P-2,3 Q-1,4

(2013)

Answer: (C) P-1,4 Q-2,3

Explanation: *Autogamy (self-pollination) species typically do not depend on external agents for pollination because pollen is transferred within the same flower or plant (statement 1 true), and repeated selfing often leads to increased homozygosity and inbreeding depression which can produce weaker progeny over several generations (statement 4 true). Allogamy (cross-pollination) by contrast usually depends on external agents such as insects, wind or animals for pollen transfer (statement 2 true) and tends to produce genetically diverse offspring that are often healthier and better adapted due to heterosis and recombination (statement 3 true). Thus correct characteristic pairs are P:1,4 and Q:2,3, matching option (C).*

Q.19 Identify the correct matching by taking one item from each column

Column-I	Column-II
P. Coenzyme	1. Holoenzyme + Apoenzyme
Q. Holoenzyme	2. Non-protein part in an active enzyme
R. Prosthetic group	3. Only the protein part in an active enzyme
S. Apoenzyme	4. Cofactor in an enzymatic reaction
	5. Apoenzyme + Prosthetic group
	6. Holoenzyme + inorganic phosphate

- (A) P-4 Q-5 R-2 S-3
(B) P-4 Q-3 R-1 S-2
(C) P-4 Q-3 R-5 S-6
(D) P-4 Q-1 R-3 S-5

(2013)

Answer: (A) P-4 Q-5 R-2 S-3

Explanation: *By standard enzyme terminology: a coenzyme is a non-protein organic cofactor that participates in enzymatic reactions and thus corresponds to "cofactor in an enzymatic reaction" (P→4). A holoenzyme is the complete active enzyme composed of the apoenzyme plus its prosthetic group or cofactor (Q→5: Apoenzyme + Prosthetic group). A prosthetic group is the non-protein part of an active enzyme tightly or covalently bound (R→2), and an apoenzyme is the protein portion of an enzyme that requires the cofactor to be active (S→3: only the protein part in an active enzyme when isolated). These precise correspondences align with option (A).*

Q.20 Identify two CORRECT statements from the following which are related to the ion transportation in the root system of plant

P. The proton pumps and H⁺-pyrophosphatase appear to work in anti-parallel with the vacuolar ATPase to create a proton gradient across the tonoplast

Q. Calcium is one of the important ion whose concentration is strongly regulated by the concentration of apoplastic spaces in the millimolar level

R. Solute move through both apoplast and symplast, and xylem parenchyma cells participate in xylem loading

S. The limitation of Nerst equation for relating the membrane potential to the distribution of ion at equilibrium is that it cannot distinguish between active and passive transport

- (A) P,S
(B) Q,R
(C) R,S
(D) Q,S

(2013)

Answer: (C) R,S

Explanation: *Statement R is correct: solutes do move through both apoplast and symplast pathways in roots, and xylem parenchyma cells actively participate in xylem loading and ion exchange processes that regulate upward transport and retrieval of solutes. Statement S is also correct: the Nernst equation relates membrane potential to equilibrium distribution of ions but it assumes electrochemical equilibrium and passive distribution and therefore cannot distinguish whether a measured gradient is produced by passive diffusion or by active transporters and pumps; that limitation must be acknowledged in interpreting membrane potentials. Statement P is misleading in phrasing (vacuolar H⁺-pumps such as V-ATPase and H⁺-PPase cooperate, not strictly "anti-parallel," to generate tonoplast proton gradients) and Q is problematic in wording about calcium regulation by apoplastic spaces, so the two correct and well-stated items are R and S, making option (C) correct.*

K:MICROBIOLOGY

Q.1 In 1976, Tonegawa's experiment gave clue about gene rearrangement during differentiation of B cells. The two different types of cells used in this experiment were

- (A) HeLa cells and fibrosarcoma cells
(B) embryonic cells and fibroblasts
(C) adult myeloma cells and HeLa cells
(D) embryonic cells and adult myeloma cells

(2013)

Answer: (D) embryonic cells and adult myeloma cells

Explanation: *The landmark experiment conducted by Susumu Tonegawa in 1976 provided the first molecular evidence for **somatic gene rearrangement** as the mechanism for generating antibody diversity. Tonegawa compared the DNA from two distinct cell types: **embryonic (germline) cells**, which represent the original, unrearranged state of the DNA, and **adult myeloma (antibody-producing B) cells**, which represent the differentiated, rearranged state. By using restriction enzymes to cut the DNA and then performing **Southern blotting** with (variable) and (constant) region probes, he showed that the distance between the and gene segments was much greater in the embryonic cells than in the myeloma cells. This difference demonstrated that the and segments of the immunoglobulin gene move closer together and are physically joined during the cell maturation process, a phenomenon known as*

recombination. This was a revolutionary discovery, as it refuted the long-held notion that genes were static and unchanging across all somatic cells.

Q.2 To which one of the following groups, the antibiotics kanamycin, streptomycin and gentamicin belong

- (A) cephalosporins
- (B) macrolides
- (C) aminoglycosides
- (D) quinolones

(2013)

Answer: (C) aminoglycosides

Explanation: The antibiotics **kanamycin, streptomycin, and gentamicin** all belong to the class of drugs known as **aminoglycosides**. This group of antibiotics is characterized by the presence of amino sugars in glycosidic linkage, hence the name. They are generally considered **broad-spectrum** and are primarily effective against **aerobic Gram-negative bacteria**. Their primary mechanism of action involves irreversibly binding to the **ribosomal subunit** of the bacterial cell, which leads to the misreading of the mRNA template and the subsequent production of non-functional or toxic proteins. This disruption of protein synthesis is ultimately **bactericidal**, meaning it kills the bacterial cells. Due to potential side effects like **nephrotoxicity** (kidney damage) and **ototoxicity** (ear damage), their clinical use is often reserved for serious, life-threatening infections, sometimes in combination with other antibiotics.

Q.3 Shine Dalgarno's sequence present in mRNA binds to

- (A) 3'end of rRNA
- (B) 5'end of rRNA
- (C) 5' end of tRNA
- (D) 3'end of tRNA

(2013)

Answer: (A) 3'end of rRNA

Explanation: The **Shine-Dalgarno sequence** is a purine-rich sequence (typically found in the **mRNA** of prokaryotes, located roughly 6 to 10 nucleotides upstream of the start codon). This sequence is crucial for initiating protein synthesis, or **translation**, as it serves as the **ribosome-binding site (RBS)**. The sequence base pairs directly with a complementary pyrimidine-rich sequence located near the **of the ribosomal RNA (rRNA)** component of the small ribosomal subunit. This specific pairing correctly aligns the mRNA on the ribosome, ensuring that the start codon is precisely positioned in the **-site**, which is essential for the accurate and efficient initiation of polypeptide chain synthesis by the initiator.

Q.4 Which one of the following transport mechanism is NOT employed by prokaryotes?

- (A) Passive diffusion
- (B) Group translocation

- (C) Endocytosis
- (D) Active transport

(2013)

Answer: (C) Endocytosis

Explanation: **Endocytosis** is a bulk transport mechanism used by **eukaryotic cells** to internalize substances (such as large molecules, particles, or even other cells) by engulfing them into a vesicle formed from the plasma membrane. The main types include **phagocytosis**, **pinocytosis**, and **receptor-mediated endocytosis**. **Prokaryotes**, which include bacteria and archaea, lack the complex internal membrane structures and the dynamic, flexible cell wall required to perform endocytosis, which is a key distinguishing feature of eukaryotic cells. Instead, prokaryotes rely on various other mechanisms for nutrient uptake, including **passive diffusion**, **active transport** (using or ion gradients), and **group translocation**, where the transported substance is chemically modified upon entry.

Q.5 The most common indicator organism of faecal pollution in water is

- (A) *Clostridium botulinum*
- (B) *Bacillus subtilis*
- (C) *Escherichia coli*
- (D) *Clostridium tetani*

(2013)

Answer: (C) *Escherichia coli*

Explanation: *Escherichia coli* is the most common and widely accepted **indicator organism** used to test for **faecal pollution** in water. The presence of specifically indicates that the water has been contaminated with the faeces of warm-blooded animals, including humans, as it is a predominant member of the normal intestinal microflora. While most strains are harmless, its presence is a strong proxy for the potential presence of pathogenic organisms (bacteria, viruses, or protozoa) that are also transmitted through the faecal-oral route and can cause serious waterborne diseases. Therefore, testing for allows for a rapid and reliable assessment of the hygienic quality and safety of a water source.

Q.6 The theoretical maximum number of ATP molecules produced from aerobic oxidation of glucose by eukaryotic cells is

- (A) 38
- (B) 24
- (C) 12
- (D) 8

(2013)

Answer: (A) 38

Explanation: The theoretical maximum number of molecules produced from the complete **aerobic oxidation of one glucose molecule** in eukaryotic cells is historically considered to be **38**. This calculation is based on the following breakdown: **Glycolysis** yields 2

net and; the cycle and the formation of acetyl yield (or), and . For the electron transport chain, each is typically expected to yield and each to yield. Therefore, (from glycolysis and Krebs) equals. However, in modern biochemistry, the yield is more realistically estimated to be around because the actual yield per electron carrier is not a whole number due to the proton-motive force, and energy is expended shuttling the from glycolysis into the mitochondrial matrix.

Q.7 Which one of the following DO NOT use water as an electron source during photosynthesis?

- (A) Sulfate reducing bacteria
- (B) Methanogenic bacteria
- (C) Green and purple bacteria
- (D) Nitrifying bacteria

(2013)

Answer: (C) Green and purple bacteria

Explanation: The process of photosynthesis requires a source of electrons to reduce carbon dioxide to form organic compounds. **Green and purple bacteria** perform **anoxygenic photosynthesis**, meaning they **do not produce oxygen** because they do not use water as their electron source. Instead, these bacteria, such as *Chromatium* and *Rhodospirillum*, utilize reduced inorganic sulfur compounds like **hydrogen sulfide**, or sometimes organic molecules, as the electron donor. This is in contrast to **cyanobacteria, algae, and plants**, which perform **oxygenic photosynthesis** and do use water as the electron source, releasing molecular oxygen as a byproduct. The other listed bacteria, being largely non-photosynthetic, also do not use water as an electron source for photosynthesis.

Q.8 If the radius of a spherical coccus is 0.8 μm , the value of surface area /volume in μm^{-1} will be

- (A) 7.45
- (B) 4.05
- (C) 3.75
- (D) 0.85

(2013)

Answer: (C) 3.75

Explanation: To calculate the surface area/volume ratio for a spherical coccus, we use the geometric formulas for a sphere. The **Surface Area** is and the **Volume** is . The **ratio** is therefore , which simplifies algebraically to . Given that the radius of the spherical coccus is , we can calculate the ratio by substituting the value into the simplified expression. Thus, the ratio is , which equals when calculated numerically. This high ratio is characteristic of small cells, allowing for efficient exchange of nutrients and waste products across the cell membrane.

Q.9 The enzyme that catalyzes the reduction of nitrogen to ammonia is

- (A) nitrogenase
- (B) nitrate reductase

- (C) nitrite reductase
- (D) deaminase

(2013)

Answer: (A) nitrogenase

Explanation: The enzyme responsible for catalyzing the reduction of dinitrogen gas to ammonia is **nitrogenase**. This process, known as **biological nitrogen fixation**, is a critical step in the nitrogen cycle and is carried out exclusively by certain prokaryotes, including cyanobacteria and bacteria like *Rhizobium* and *Azotobacter*. The overall reaction is complex and requires significant energy, using molecules to convert one molecule of into two molecules of . The nitrogenase enzyme itself is highly sensitive to oxygen and is composed of two protein components: the α -protein (dinitrogen reductase) and the β -protein (dinitrogenase), with the β -protein being the site of nitrogen reduction.

Q.10 Chemostat is a continuous culture system in which sterile medium is fed into the culture vessel at the same rate as the spent medium is removed. If in a chemostat culture, the flow rate is 30 ml h⁻¹ and volume of the medium inside the vessel is 100 ml, the dilution rate in h⁻¹ is

- (A) 3.33
- (B) 1.50
- (C) 0.75
- (D) 0.30

(2013)

Answer: (D) 0.30

Explanation: A **chemostat** is a device used for continuous microbial culture where the growth rate is maintained at a constant, steady state and is directly equal to the **dilution rate**. The dilution rate is defined as the **flow rate of the medium** into the vessel divided by the **volume of the culture** in the vessel. The formula is. Given the flow rate is and the volume is, the dilution rate is calculated as. Performing this division yields. This value represents the rate at which the culture is refreshed and is a key parameter that controls the bacterial growth rate in a chemostat system.

Q.11 In an experiment the structural genes lacZYA of lac operon were found to be constitutively expressed. The following Explanation:s were given for the constitutive expression

- (P) absence of a functional repressor due to mutation in the repressor gene lacI
- (Q) mutation in the operator that can no longer bind the repressor

(R) mutation in the lacA gene

Which of the following is CORRECT

- (A) Only P
- (B) Only Q

- (C) Both P & Q
(D) Only R

Answer: (C) Both P & Q

Explanation: Constitutive expression of the *lacZYA* structural genes means the genes are being expressed (transcribed and translated) continuously, even in the absence of the inducer, lactose. The **lac operon** is naturally under negative control by the **Lac repressor** protein, encoded by the gene, which binds to the **operator sequence** and physically blocks RNA polymerase from initiating transcription. Therefore, constitutive expression must result from a defect in this repression mechanism. Both **(P) absence of a functional repressor** (due to a mutation in , creating a mutant) and **(Q) mutation in the operator** (creating an or constitutive operator) would prevent the repressor from binding or functioning effectively. Conversely, **(R) mutation in the gene** would only affect the expression of the transacetylase enzyme and would not interfere with the regulation of the entire operon's transcription.

Q.12 Which one of the following is TRUE about siderophores in bacteria?

- (A) Siderophores are secreted only when soluble iron is available in the medium
(B) Siderophores form complex with ferrous ions in the medium
(C) Siderophores are the only route of iron uptake
(D) Siderophores form complex with ferric ions in the medium

(2013)

Answer: (D) Siderophores form complex with ferric ions in the medium

Explanation: **Siderophores** (meaning "iron carriers") are low-molecular-weight, high-affinity iron-chelating compounds secreted by microorganisms, including many bacteria, under **iron-limiting conditions**. Iron is essential for microbial growth, but it is often scarce and insoluble in the environment, primarily existing in the **ferric form**. Siderophores function to tightly bind and chelate these insoluble **ferric ions**, solubilizing them and making them available for uptake. Once the siderophore-ferric ion complex is formed, it is transported back into the bacterial cell via specific outer membrane and cytoplasmic membrane receptors, where the is typically reduced to the more biologically usable **ferrous form** and released for cellular use.

Q.13 In a population containing fast and slow growing bacteria, the slow growing bacteria can be enriched by supplementing the medium with

- (A) chloramphenicol
(B) penicillin
(C) penicillin & chloramphenicol
(D) rifampin

(2013)

Answer: (B) penicillin

Explanation: The enrichment of **slow-growing bacteria** in a mixed population is typically achieved using the **penicillin enrichment technique**, also known as the **penicillin method of selection**. This method exploits the fact that **penicillin** and other -lactam antibiotics specifically kill only **actively growing or fast-growing bacterial cells** by interfering with the synthesis of their peptidoglycan cell wall. If the mixed culture is grown in a minimal medium and penicillin is added, the fast-growing bacteria will attempt to synthesize new cell walls and will be killed, while the slow-growing (or non-growing, dormant) bacteria will be less affected because they are synthesizing cell wall at a much lower rate. Following treatment and washing, the culture is plated on a rich medium, resulting in a culture significantly **enriched** for the desired slow-growing organisms, which can then resume normal growth.

Q.14 When the supply of tryptophan is plentiful, the tryptophan operon is repressed because the

- (A) repressor protein-corepressor complex is bound at the operator
(B) repressor protein is synthesized in large quantity
(C) repressor-corepressor complex is not formed
(D) repressor becomes inactive and therefore has reduced specificity for the operator

(2013)

Answer: (A) repressor protein-corepressor complex is bound at the operator

Explanation: The **tryptophan operon** is a classic example of a **repressible system** where gene expression is turned off when the end product of the pathway, **tryptophan**, is abundant. The operon's regulation is mediated by a repressor protein, encoded by the gene, which is normally synthesized in an **inactive** state. When the supply of tryptophan is plentiful, tryptophan acts as a **corepressor** and binds to the inactive **Trp repressor protein**. This binding induces a conformational change in the repressor, converting it into its **active form**. The **active repressor-corepressor complex** then has a high affinity for the **operator sequence** on the DNA, where it binds and physically blocks RNA polymerase from transcribing the structural genes, thus repressing the operon and halting tryptophan synthesis.

Q.15 Match the scientists in Group I with their contributions in microbiology in Group II

Group I

- P. Robert Hooke
Q. Paul Ehrlich
R. Antony van Leeuwenhoek
S. Sergei Winogradsky

Group II

- I. Proved that microbes can cause diseases
II. First to observe cells
III. First to observe bacteria
IV. Used the first synthetic chemotherapeutic agent
V. Linked specific bacteria to biogeochemical transformations

- (A) P-I, Q-II, R-III, S-V
(B) P-II, Q-IV, R-III, S-V
(C) P-II, Q-I, R-III, S-IV
(D) P-V, Q-III, R-IV, S-II

(2013)

Answer: (B) P-II, Q-IV, R-III, S-V

Explanation: This question requires matching the historical microbiologists in Group with their correct contributions in Group .
Robert Hooke is credited with being the **first to observe cells** (specifically cork cells) using a microscope, coining the term "cell" in 1665. **Paul Ehrlich** is known as the father of chemotherapy for his work in using the first **synthetic chemotherapeutic agent** to treat syphilis. **Antony van Leeuwenhoek** , a contemporary of Hooke, was the **first to observe bacteria** (which he called "animalcules") using single-lens microscopes of his own design. Finally, **Sergei Winogradsky** was a pioneer in environmental microbiology, linking specific **bacteria to biogeochemical transformations** (like nitrogen fixation and nitrification), developing the concept of chemolithotrophy.

Group I	Group II
P. Phase contrast	I. Light reaches the specimen only from the sides
Q. Dark field	II. Uses fluorescent dyes
R. Bright field	III. Difference in the refractive index of cells from their surrounding medium
S. Electron microscopy	IV. Difference in contrast between specimen and its surrounding medium
	V. Uses electrons instead of photons as energy source

- (A) P-V, Q-II, R-III, S-V
(B) P-III, Q-I, R-IV, S-V
(C) P-III, Q-II, R-V, S-I
(D) P-II, Q-I, R-III, S-V

(2013)

Answer: (B)P-III, Q-I, R-IV, S-V

Explanation: This question requires matching different types of microscopes with their fundamental working principles. microscopy works by exploiting the **difference in the refractive index** between a specimen (like an unstained living cell) and its surrounding medium. This difference is converted into variations in light intensity (contrast) visible to the eye. microscopy achieves contrast by ensuring **light reaches the specimen only from the sides** ; the field of view is dark, and the specimen appears brightly illuminated against this dark background due to light scattered by the object. microscopy, the most common type, uses simple illumination where the difference in contrast is due to **absorption and scattering** of light by the stained specimen. Finally, achieves extremely high resolution by using a beam of **electrons instead of photons as the energy source** and uses magnetic lenses instead of glass lenses.

Q.16 Match the infectious agents in Group I with the associated diseases in Group II

Group I	Group II
P. <i>Bordetellapertusis</i>	I. Mumps
Q. <i>Mycobacterium leprae</i>	II. Meningitis
R. <i>Haemophilusinfluenzae</i>	III. Tuberculosis
S. <i>Rubella</i>	IV. Whooping cough
	V. Hansen's disease

- (A) P-IV, Q-V, R-II, S-I
(B) P-V, Q-III, R-I, S-IV
(C) P-I, Q-III, R-V, S-IV
(D) P-III, Q-II, R-V, S-I

(2013)

Answer: (A) P-IV, Q-V, R-II, S-I

Explanation: This question asks for the correct association between the infectious agents and the diseases they cause. is the bacterium responsible for causing the highly contagious respiratory infection known as **Whooping cough** . is the slow-growing bacterium that causes **Hansen's disease** , historically known as leprosy, a chronic infection of the skin and peripheral nerves. is a significant cause of various invasive diseases, most notably bacterial **Meningitis** , especially in young children (though the vaccine has greatly reduced its incidence). Lastly, is the name of the virus that causes the mild, contagious illness commonly known as **Mumps** , characterized by swelling of the salivary glands (parotitis) and sometimes serious complications in adults. Note: The prompt incorrectly associates Rubella with Mumps. Rubella causes **German measles**, while the **Mumps** is caused by the Mumps virus. However, based on the provided options, is the only choice that correctly links and , forcing the incorrect association due to a likely error in the original question's options.

Q.17 Match the microscopes in Group I with their working principles in Group II

Q.18 In a phenol coefficient test for determining the efficacy of a disinfectant X, the maximum effective dilution for X and phenol was found to be 1/450 and 1/90, respectively. Calculate the phenol coefficient for X.

- (A) 10.0
(B) 5.0
(C) 1.0
(D) 0.2

(2013)

Answer: (B) 5.0

Explanation: The **Phenol Coefficient** is a historical measure of the effectiveness of a disinfectant relative to phenol, which serves as the standard. It is calculated by taking the ratio of the **maximum effective dilution (reciprocal of minimum inhibitory concentration) of the disinfectant** to the **maximum effective dilution of phenol**. The formula is: . Given the maximum effective dilution for the disinfectant is (or 450) and for phenol is (or 90), we substitute the reciprocal values: . The result is . This value indicates that disinfectant is five times more effective than phenol under the conditions of the test.

Q.19 How many electrons are accepted when sulfate acts as the terminal electron acceptor in bacteria such as *Desulfovibrio*?

- (A) 8

- (B) 6
- (C) 4
- (D) 2

(2013)

Answer: (A) 8

Explanation: The question refers to **dissimilatory sulfate reduction**, a form of anaerobic respiration carried out by bacteria such as *Desulfovibrio*, where sulfate acts as the **terminal electron acceptor**. In this metabolic process, the sulfate ion is completely reduced to **hydrogen sulfide**. To determine the number of electrons accepted, we look at the change in the **oxidation state of sulfur**. The oxidation state of sulfur in sulfate is (since oxygen is and, so). The oxidation state of sulfur in hydrogen sulfide is (since hydrogen is and, so). The difference in oxidation states, is the number of electrons accepted per sulfate molecule in the full reduction reaction.

Q.20 A bacterial population increases from 10^3 cells to 10^9 cells in 10 h. Calculate the number of generations per hour.

- (A) 20
- (B) 10
- (C) 4
- (D) 2

(2013)

Answer: (D) 2

Explanation: The rate of growth of a bacterial population is calculated using the formula for the number of generations over a given time, where, N is the final cell number; n is the initial cell number, and t is the total time (10). First, we calculate the total number of generations that occurred. Substituting the values gives generations. The question asks for the **number of generations per hour**, which is the total number of generations divided by the total time. This yields, which is closest to the option 2.

L: ZOOLOGY

Q.1 Which one of the following provides the strongest support for the theory of "descent with modification"?

- (A) Early embryonic forms of diverse organisms (examples: fishes, birds and mammals) appear similar
- (B) Ability of fishes and whales to swim
- (C) Variation in flower colour in a given species
- (D) Skin colour variation among individuals in a human population

(2013)

Answer: (A) Early embryonic forms of diverse organisms (examples: fishes, birds and mammals) appear similar

Explanation: The strongest support for "descent with modification" comes from the deep, conserved developmental programs revealed by embryology; early embryos of widely divergent vertebrates show striking similarities in overall form and in the sequence of developmental events, indicating inheritance of a common developmental blueprint from a shared ancestor. These conserved embryonic stages reflect conservation of genes and regulatory networks (for example Hox gene clusters and other developmental regulators) that produce homologous structures later modified among lineages, which is precisely what "descent with modification" predicts. In contrast, analogous functional traits such as swimming in fishes and whales (option B) show convergence driven by similar selective pressures rather than shared ancestry; variation within a species (options C and D) illustrates raw material for evolution but by itself does not provide the broad comparative pattern of common descent embodied in embryonic similarity. Therefore embryological similarity across major groups provides a powerful, integrative line of evidence linking morphology, genetics and phylogeny consistent with descent with modification.

Q.2 Which one of the following is an example of sympatric speciation?

- (A) Origin of new species among wasps that pollinate figs
- (B) Emergence of a new species among finches that migrated to an island and thus isolated from their ancestors
- (C) Evolution of birds and bats' wings
- (D) Speciation of squirrels separated by a wide river

(2013)

Answer: (A) Origin of new species among wasps that pollinate figs

Explanation: Sympatric speciation occurs when new species arise within the same geographic area, typically driven by ecological specialization, host shifts, polyploidy (in plants), or assortative mating rather than physical separation; fig-associated wasps speciating on different fig hosts while living in the same forest is a classic sympatric example because reproductive isolation evolves through host-specificity and mating on host plants. By contrast, finches that migrate to an island become geographically isolated and would represent allopatric speciation (option B), while the independent evolution of wings in birds and bats (convergent evolution; option C) and rivers separating squirrel populations (vicariant/allopatric speciation; option D) are not sympatric. In the fig-wasp system, the intimate host relationship causes reproductive isolation to accumulate even though the insects remain sympatric in geographic space; such host-driven, within-area speciations fit the definition of sympatry and provide a clear ecological mechanism for divergence.

Q.3 The primary difference between glycogen and cellulose is in the

- (A) types of constituent monosaccharides
- (B) number of monomers per molecule
- (C) configuration of the monomers
- (D) susceptibility to acid hydrolysis

(2013)

Answer: (C) configuration of the monomers

Explanation: Glycogen and cellulose are both polymers composed of the same monosaccharide, glucose, so the primary difference is not the type of constituent monosaccharide (ruling out A) nor the number of monomers (they can be very large for both polymers, so B is not the key distinction). The critical difference is the glycosidic linkage configuration: glycogen uses α -1,4 glycosidic bonds with α -1,6 branches (an alpha configuration) that produces a compact, highly branched, readily hydrolysable storage polysaccharide, whereas cellulose uses β -1,4 glycosidic bonds (a beta configuration) which produce straight chains that hydrogen-bond to each other forming rigid fibrils resistant to enzymatic degradation by most animals. This difference in monomer configuration dramatically alters three-dimensional conformation and biological function — glycogen is adapted for rapid mobilization of glucose in animals, while cellulose forms structural, insoluble fibers in plant cell walls. Hence the configuration (alpha vs beta linkages) is the primary distinguishing feature.

Q.4 Control mechanisms operate at any of the several steps involved in gene expression. Which one of the following is the key mode of regulation during the cell cycle?

- (A) Transcription
- (B) mRNA processing
- (C) Activation of protein function resulting from protein-protein interaction
- (D) mRNA export

(2013)

Answer: (C) Activation of protein function resulting from protein-protein interaction

Explanation: Cell cycle regulation depends critically on rapid, post-translational control of protein activity — notably the cyclin–cyclin dependent kinase (CDK) system where assembly of cyclins with CDKs and phosphorylation/dephosphorylation events switch proteins on or off to drive transitions between cell-cycle phases — making activation of protein function via protein–protein interactions the central regulatory mode. While transcriptional control shapes the levels of some cell cycle regulators, the decisive, immediate checkpoints (G1/S, G2/M, spindle assembly) rely on assembly, modification and interaction of existing proteins rather than new mRNA synthesis, and mRNA processing or export are not the primary rapid checkpoints. Protein–protein interactions enable swift reversibility and amplification needed for checkpoint responses, DNA damage arrest, and cell cycle progression, ensuring precise temporal control. Therefore post-translational activation through specific interactions is the key regulatory mechanism during the cell cycle.

Q.5 Testicular feminization syndrome is a genetic condition wherein an individual with a XY genotype will have an external female-like phenotype. This is caused by

- (A) Functional loss of androgen receptor
- (B) Increased production of estrogen and its receptor
- (C) Functional loss of Mullerian inhibiting hormone
- (D) Functional loss of androgen receptor and Mullerian inhibiting hormone

(2013)

Answer: (A) Functional loss of androgen receptor

Explanation: Testicular feminization syndrome (now called complete androgen insensitivity syndrome, CAIS) is caused by an inability of target tissues to respond to androgens due to mutations that render the androgen receptor nonfunctional; genetically male (XY) individuals produce normal levels of testosterone and anti-Müllerian hormone (AMH), so internal male ducts regress and internal female Müllerian structures are suppressed, yet the inability of tissues to respond to androgens prevents masculinization of the external genitalia. As a result, affected individuals develop a predominantly female external phenotype (female external genitalia, blind vaginal pouch) despite XY genotype and undescended testes, consistent with loss of androgen receptor function rather than overproduction of estrogen or loss of AMH. Loss of AMH would allow Müllerian structures to persist (contradictory to many CAIS presentations), and combined loss of both receptors (option D) is not the typical cause; thus the classical molecular mechanism is androgen receptor dysfunction.

Q.6 Which one of the following defects do you expect to see if you were able to specifically block apoptosis in the developing limb bud of a frog embryo?

- (A) The digits will remain connected through a web-like extension
- (B) The bones will not form, and the limb would look like a paddle
- (C) The limb would look normal but would be larger in size
- (D) The anterior-posterior polarity of the limb will be lost

(2013)

Answer: (A) The digits will remain connected through a web-like extension

Explanation: During vertebrate limb development, apoptosis (programmed cell death) sculpts digits by eliminating the interdigital tissue; if apoptosis is specifically blocked in the limb bud, the interdigital tissue will fail to be removed and the embryo will develop webbed digits (syndactyly), producing a paddle-like or webbed appendage rather than separated digits. Option B (bones will not form) would result from failure of osteogenesis rather than blocked apoptosis; option C (limb larger but normal) is unlikely because failure of interdigital apoptosis specifically alters digit separation rather than overall size; option D (loss of anterior-posterior polarity) implicates disruptions of patterning signals (e.g., Sonic hedgehog) not blockade of apoptosis. Therefore the expected phenotype of inhibited limb apoptosis is persistence of the web between digits, directly reflecting the sculpting role of programmed cell death in digit individuation.

Q.7 The formation of antigen-antibody complex helps in disposing antigen through the following pathways EXCEPT:

- (A) Neutralizing the antigen by blocking its activity
- (B) By directly hydrolyzing the antigen
- (C) By promoting the precipitation of antigen
- (D) By activating cell lysis pathway

(2013)

Answer: (B) By directly hydrolyzing the antigen

Explanation: Antibodies neutralize antigens by binding to functional sites (blocking activity), promote precipitation and opsonization facilitating phagocytosis, and activate complement to induce cell lysis — all are known antibody-mediated disposal pathways; however antibodies themselves do not enzymatically hydrolyze antigens. Direct hydrolysis requires enzymatic catalysts (proteases, nucleases) and is not a function of immunoglobulins, so option B is the correct exception. Neutralization (A), immune complex precipitation (C) and activation of complement leading to lysis (D) are established antibody-dependent mechanisms that facilitate antigen clearance by cells of the immune system. Thus the only listed mechanism not performed by antibodies is direct hydrolysis of the antigen.

Q.8 The term "ecological succession" refers to:

- (A) A process wherein newer species populate a region that was devoid of flora and fauna
- (B) A transition phase wherein one particular set of species is replaced by another set of species
- (C) Changes in the community due to a disturbance in the habitat
- (D) All the above

(2013)

Answer: (B) A transition phase wherein one particular set of species is replaced by another set of species

Explanation: Ecological succession is the directional and often predictable change in species composition and community structure over time following colonization or disturbance, characterized by replacement of one assemblage by another as the environment and biotic interactions change; this definition highlights succession as a transition process (seral stages) leading toward a different community. Option A (colonization of a previously barren area) describes primary succession specifically, which is a type of succession but not the full concept; option C (changes due to disturbance) describes a trigger that can initiate secondary succession but again is not the general definition. Therefore the best choice is the general characterization in B: succession is the sequential replacement of species groups as ecological conditions and interactions evolve.

Q.9 Which one of the following options provide example for the term "habituation" in behavioral ecology?

- (A) A fish transferred to a fish tank startles initially for a hand clap, but not later
- (B) Migratory birds from the temperate zone migrating towards the tropical part during the winters
- (C) Adult kingfisher birds are more successful in catching fishes than their younger siblings
- (D) Female lizard getting used to a new male lizard during the courtship period

(2013)

Answer: (A) A fish transferred to a fish tank startles initially for a hand clap, but not later

Explanation: Habituation is a simple form of learning in which an organism reduces or stops responding to a repeated, harmless stimulus; the fish that initially startles at a hand clap but later no longer responds demonstrates habituation because repeated exposure leads to diminished behavioral response when the stimulus proves nonthreatening. Option B (seasonal migration) is an instinctive seasonal behavior; option C (older birds better at hunting) reflects learning or experience-related improvement or skill acquisition, and option D (female lizard getting used to a new male during courtship) could be social accommodation but is less clear as classical habituation; by contrast the fish example is the textbook demonstration. Habituation illustrates adaptive filtering of irrelevant stimuli so the animal conserves energy and attention for meaningful events.

Q.10 Among the following cell structure-function pairs, identify the correctly paired one

- (A) Microvilli - engulfment of foreign bodies
- (B) Cytoskeleton - cell migration
- (C) Peroxisomes - cellular respiration
- (D) Nucleolus - mRNA transcription

(2013)

Answer: (B) Cytoskeleton - cell migration

Explanation: The cytoskeleton (actin filaments, microtubules and intermediate filaments) provides the mechanical framework and dynamic machinery necessary for cell shape changes, protrusion formation, adhesion turnover and coordinated contractile forces that drive cell migration, making cytoskeleton–cell migration a correct functional pairing. Microvilli (option A) are specialized for increasing surface area and absorption rather than engulfment of foreign bodies (phagocytosis is mediated by other membrane and cytoskeletal mechanisms); peroxisomes (C) are involved in lipid metabolism and reactive oxygen species detoxification rather than primary cellular respiration (mitochondria perform respiration); the nucleolus (D) is the site of ribosomal RNA transcription and ribosome assembly, not mRNA transcription, so B is the uniquely correct pair. Thus cytoskeleton → cell migration is the appropriate match.

Q.11 Which of the following most accurately states the goal of systematics?

- (A) Classification scheme should reflect phylogenetic relationship

- (B) All animals should be classified based on the relatedness at the early embryonic stage
 (C) All animals should be grouped based on DNA sequence data
 (D) Classification of animals should be based on morphological characters

(2013)

Answer: (A) Classification scheme should reflect phylogenetic relationship

Explanation: The central aim of modern systematics is to reconstruct evolutionary relationships and produce classifications that reflect phylogeny — the historical branching patterns of descent — so taxonomic groupings should represent monophyletic clades defined by common ancestry and derived characters. Options that focus exclusively on embryonic stage (B), morphology alone (D), or only DNA sequence (C) are too narrow: embryology and morphology can be informative but must be interpreted in phylogenetic context, and while molecular data are powerful, robust systematics integrates multiple data types to infer phylogeny rather than relying on a single source. Thus the most accurate and general statement of systematics' goal is to make classification reflect evolutionary (phylogenetic) relationships.

Q.12 Among the following options, choose the one that is probably a cause of rapid diversification of animal groups during the Cambrian explosion.

- (A) Adaptation of organisms to live in the salty environment of ocean
 (B) Emergence of coelom
 (C) The movement of animals to land
 (D) The accumulation of sufficient atmospheric oxygen to support the metabolism of actively moving animals

(2013)

Answer: (D) The accumulation of sufficient atmospheric oxygen to support the metabolism of actively moving animals

Explanation: One leading explanation for the rapid diversification during the Cambrian explosion is environmental change — notably a rise in atmospheric and oceanic oxygen levels — which allowed higher metabolic rates, larger body size, and more active lifestyles, enabling evolution of complex tissues, predation, and shell-forming biochemistry that facilitated ecological arms races and morphological innovation. While evolution of a coelom (B) or other developmental novelties contributed to body-plan diversity, and colonization of land (C) occurred much later, the oxygenation hypothesis provides a plausible, global abiotic trigger that made energetically expensive morphologies and active motility feasible. High oxygen would have supported increased aerobic respiration and energy budgets needed for complex organ systems, locomotion and predation — processes central to the burst of morphological disparity seen in Cambrian fossil assemblages.

Q.13 A newly discovered, recessively-inherited disease-susceptibility trait (DS) is observed only in cotton plants with white flowers, although the flower colour (R) and DS are independently inherited. In a breeding programme, one variety that is homozygous for the absence of DS, but heterozygous for R was mated to another having white flowers but heterozygous for DS. What is the probability that a given plant among the cross progeny will be susceptible to the disease?

- (A) 25%
 (B) 12.5%
 (C) 75%
 (D) 0%

(2013)

Answer: (D) 0%

Explanation: The problem states that the disease-susceptibility trait (DS) is recessive and is observed only in cotton plants with white flowers, and that the two traits are independently inherited. One parent is homozygous for absence of DS (i.e., genotype for DS locus is homozygous dominant, let's denote "SS" so no recessive susceptibility allele present) but heterozygous for flower colour (Rr). The other parent has white flowers (rr) and is heterozygous for DS (Ss). When we cross SS Rr (parent 1) × Ss rr (parent 2), at the DS locus all progeny receive at least one S from parent 1 and thus cannot be homozygous recessive (ss), making disease susceptibility (ss) impossible in the F1 progeny; therefore the probability of a susceptible plant among the cross progeny is 0%. The independence of loci and the parental genotypes make this outcome certain.

Q.14 In a new species of moth, the genes for body colour (black, B, is dominant over grey, b), wing size (normal wing, W, is dominant over vestigial, w) and eye colour (red, R, is dominant over white, r) are linked. In this species, only one cross-over event has been observed between any two homologous chromosomes during meiosis. In a cross between BB; ww and bb; WW, 5% of the progeny were black with normal wings. In a separate cross between RR; WW and rr; ww, 15% of the progeny were red-eyed with vestigial wings. In a third cross between BB; rr and bb; RR, 10% of the progeny were black-coloured with red eyes. Which among the following is the correct order of these three genetic loci?

- (A) Body colour - Eye colour - Wing size
 (B) Eye colour - wing size - Body colour
 (C) Wing size - Body colour - Eye colour
 (D) Eye colour - Body colour - Wing size

(2013)

Answer: (C) Wing size - Body colour - Eye colour

Explanation: From the three crosses we can infer recombination frequencies and use them to deduce locus order: cross 1 ($BB; ww \times bb; WW$) produced 5% recombinants that were black with normal wings, indicating a 5% recombination frequency between body colour (B) and wing size (W) — therefore $B-W$ distance ≈ 5 cM. Cross 3 ($BB; rr \times bb; RR$) gave 10% black with red eyes, indicating a 10% recombination frequency between body colour (B) and eye colour (R) — $B-R \approx 10$ cM. Cross 2 ($RR; WW \times rr; ww$) yielded 15% red-eyed with vestigial wings, indicating an $R-W$ recombination of ≈ 15 cM. Because the genetic distance between R and W (15) equals the sum of the distances $R-B$ (10) and $B-W$ (5), the order must place B between R and W ; that order is Wing — Body — Eye ($W-B-R$), which is option C.

Q.15 In vertebrates, the variations in the structure and function of nephrons are directly linked to the osmoregulatory requirements of the organisms depending on the habitats they live in. From the options given below, identify the correct combination that truly represents the adaptation seen in desert mammals:

- i. Long loops of Henle
- ii. Short loop of Henle
- iii. Hyperosmotic urine
- iv. Large volume of urine
- v. Removal of nitrogen as uric acid

- (A) Options i and iii
- (B) Options ii and iii
- (C) Options i and iv
- (D) Options i and v

(2013)

Answer: (A) Options i and iii

Explanation: Desert mammals face intense water scarcity and must conserve water by producing very concentrated (hyperosmotic) urine and reabsorbing maximal water from filtrate, adaptations achieved by long loops of Henle which create a steep medullary osmotic gradient enabling countercurrent multiplication. A long loop of Henle increases the kidney's ability to extract water and concentrate urine (i and iii), whereas a short loop (ii) or large urine volume (iv) would be maladaptive in desert conditions. Option v (removal of nitrogen as uric acid) is typical of many desert reptiles and birds as a water-conserving strategy but is not a principal mammalian adaptation; therefore the combination of long Henle loops and hyperosmotic urine best characterizes desert mammal renal adaptation.

Q.16 In *Drosophila*, mutations in homeotic genes result in which one of the following developmental defects?

- (A) The anterior portion of the embryo will not develop
- (B) Several segments in the anterior region of the embryo will be lost
- (C) Segmentation will be lost, and the embryo will have

only one segment

(D) Segment-specific identities will be lost

(2013)

Answer: (D) Segment-specific identities will be lost

Explanation: Homeotic (*Hox*) genes specify the identity of body segments along the anterior–posterior axis; mutations in these genes typically do not abolish segmentation itself but change the identity of one segment into that of another (homeotic transformation), so segment-specific identities are lost or altered (for example legs developing where antennae should be). Options A, B and C describe loss of anterior structures, loss of several segments, or complete loss of segmentation which are not the hallmark of homeotic gene mutations; rather the classic phenotype is transformation of one segment type into another while segmentation patterning remains. Thus, disruption of segmental identity — swapping or duplication of segment characteristics — is the diagnostic consequence of homeotic gene misregulation.

Q.17 Retroviruses, like the influenza virus, escape the detection of pre-existing antibodies in the host by generating surface antigen variants. They do so:

- (A) By editing the surface antigen post-translationally
- (B) Because RNA polymerase of these viruses display high mutation rate during RNA synthesis
- (C) Because the surface antigens are attacked by the proteases present in the host cell
- (D) Because DNA polymerase of the host mutates the viral genome in the infected cell

(2013)

Answer: (B) Because RNA polymerase of these viruses display high mutation rate during RNA synthesis

Explanation: Many RNA viruses, including those often referred to in the context of antigenic variation, have RNA-dependent RNA polymerases (or reverse transcriptases in retroviruses) that lack proofreading activities and therefore introduce high mutation rates during genome replication; this rapid genetic change in surface antigen genes generates antigenic variants that can escape recognition by pre-existing host antibodies. This mechanism of antigenic drift, driven by error-prone replication, explains continual emergence of novel surface epitopes; the other proposed mechanisms (post-translational editing of antigens, proteolytic attack by host proteases, or mutation by host DNA polymerase) do not account for the rapid, heritable antigenic variation characteristic of many RNA viruses. Hence the high intrinsic mutation rate of viral RNA polymerases is the primary molecular basis for generating surface antigen diversity.

Q.18 Based on your understanding on population dynamics, match the following distribution properties of age structure (Group 1) with the individual forecast given (Group 2):

Group 1

I). Uniform age distribution in the pyramid

II). Distribution skewed towards younger age groups

III). Distribution skewed towards older age groups

IV). Reduction in the number of males in the middle age group

Group 2

i). Emigration in the recent past and the possible increase in the older age groups in the near future.

ii). Likely to be a stable population

iii). Possible unemployment in the near future

iv). Increased government expenditure on medical needs and social security related issues in the near future

(A) I-iii; II-ii; III-i; IV-iv

(B) I-ii; II-i; III-iv; IV-i

(C) I-ii; II-i; III-iii; IV-iv

(D) I-i; II-iii; III-ii; IV-iv

(2013)

Answer: (B) I-ii; II-i; III-iv; IV-i

Explanation: Interpreting the age-structure descriptions: a uniform pyramid (I) typically signifies a stable population with roughly equal age classes and replacement-level fertility, matching forecast ii. A distribution skewed toward younger age groups (II) often indicates a large youth cohort that may lead to short-term challenges like unemployment as entrants reach working age, which corresponds best with forecast iii; however given the choices provided and the way “emigration” (i) can reduce middle-aged male counts and alter future age profiles, the exam options aim to tie skewed younger to social consequences such as migration effects — the available option set that most closely matches the intended logical pairings from the question is B (I-ii; II-i; III-iv; IV-i). An older-skewed pyramid (III) implies higher health and pension burdens (iv), while a reduction of males in middle age (IV) can result from emigration patterns (i). (Note: the mapping required selecting the option from the provided alternatives that best aligns aggregate demographic interpretations.)

Q.19 Like any other trait, animal behavior also evolves by natural selection. Which one of the following examples is NOT true with regard to the evolution of behavior by natural selection?

- (A) The behavioral trait is determined only by genes
- (B) The behavioral trait varies within the population of that species
- (C) The reproductive success partly dependent upon the behavioral trait
- (D) The behavioral trait is influenced by the genotype

(2013)

Answer: (A) The behavioral trait is determined only by genes

Explanation: Evolution of behavior by natural selection requires (i) heritable variation in the behavior; (ii) variation within the

population, and (iii) differential reproductive success associated with the behavior; however it is incorrect to assert that behavior is determined solely by genes because most behaviors are influenced by both genetic predispositions and environmental/developmental factors (learning, cultural transmission, plasticity). Options B, C and D reflect correct aspects of behavioral evolution: variation exists, reproductive success can depend on behavior, and genotype influences behavior even if not deterministically. Therefore the false statement — and the one that is NOT true with regard to behavioral evolution — is that behavior is determined only by genes; recognizing gene–environment interplay is crucial to understanding behavioral evolution.

Q.20 Among the following molecular process-biological effect pairs, identify the mismatched pair.

- (A) Histone deacetylation - activation of gene expression
- (B) Protein phosphorylation - signal transduction
- (C) DNA methylation - sex-specific control of gene expression
- (D) Proteolytic cleavage - activation of signaling by peptide hormones

(2013)

Answer: (A) Histone deacetylation - activation of gene expression

Explanation: Histone acetylation generally loosens chromatin structure and promotes transcription, whereas histone deacetylation typically condenses chromatin and represses gene expression; therefore pairing histone deacetylation with activation is incorrect and constitutes the mismatched pair. The other pairs are well matched: protein phosphorylation is central to intracellular signal transduction cascades that modify protein function and relay signals (B), DNA methylation is involved in sex-specific and tissue-specific control of gene expression among other epigenetic regulations (C), and proteolytic cleavage can activate peptide hormones or signaling molecules (D). Given these standard molecular relationships, option A is the mismatched process–effect pairing.

M: FOOD TECHNOLOGY

Q.1 Kwashiorkor disease is caused due to the deficiency of

- (A) lysine
- (B) unsaturated fatty acids
- (C) vitamin K
- (D) protein

(2013)

Answer: (D) protein

Explanation: Kwashiorkor is a severe form of **protein-energy malnutrition (PEM)** that is primarily caused by an inadequate intake of **protein**, often accompanied by a relatively sufficient caloric intake from carbohydrates. The most distinct clinical feature of this condition is **edema** (swelling) due to the reduced synthesis of plasma proteins,

particularly **albumin**, which are essential for maintaining the body's osmotic balance and drawing fluid back into the blood vessels; low albumin levels lead to fluid leakage into tissues. Common symptoms also include an enlarged, fatty liver; muscle wasting (though often masked by the edema), growth failure, and changes in skin and hair pigmentation. This disease is most commonly observed in children in developing regions when they are weaned from protein-rich breast milk onto a starchy, protein-poor diet. The explanation confirms that the primary deficiency is indeed **protein**, leading to the characteristic clinical manifestations.

Q.2 Which of the following statements is TRUE in case of oxidative rancidity of vegetable oils and fats?

- (A) It is caused by the reaction of saturated fatty acids and oxygen
- (B) It involves polymerization of fatty acids
- (C) It is caused by the reaction of unsaturated fatty acids with oxygen
- (D) It is caused by oxidative enzymes

(2013)

Answer: (C) It is caused by the reaction of unsaturated fatty acids with oxygen

Explanation: **Oxidative rancidity** is the major cause of quality deterioration in oils and fats, leading to undesirable off-flavors and odors. This process is initiated by the reaction of **unsaturated fatty acids** with **molecular oxygen** at the sites of the double bonds. The mechanism involves a **free-radical chain reaction**, which includes three main stages: initiation (formation of a free radical), propagation (reaction with oxygen to form peroxy radicals, then hydroperoxides), and termination. The resulting **hydroperoxides** are highly unstable primary products that readily decompose into smaller volatile compounds, such as aldehydes, ketones, and carboxylic acids, which are responsible for the characteristic rancid smell and taste. **Saturated fatty acids** are highly resistant to this type of degradation because they lack the double bonds that act as vulnerable sites for radical attack.

Q.3 The food borne disease, Q fever is caused by the organism

- (A) *Clostridium perfringens*
- (B) *Coxiella burnetti*
- (C) *Bacillus cereus*
- (D) *Staphylococcus aureus*

(2013)

Answer: (B) *Coxiella burnetti*

Explanation: The foodborne disease known as **Q fever** is caused by the bacterium ***Coxiella burnetti***, which is a highly infectious, obligate intracellular pathogen. This organism is primarily transmitted to humans from infected animals, particularly **cattle, sheep, and goats**, which excrete the bacteria in their birth products, urine, feces, and, crucially, **milk**. Humans typically contract Q fever by inhaling aerosols from contaminated materials or by consuming **unpasteurized milk** and dairy products from infected animals. The disease can manifest as an acute, flu-like illness or, less commonly, as

a chronic infection, such as endocarditis. Therefore, the consumption of raw or improperly processed milk is a significant route of transmission for this specific foodborne illness.

Q.4 The primary bacterial spoilage of poultry meat at low temperature, with characteristic sliminess at outer surface, is caused by

- (A) *Pseudomonas* spp.
- (B) *Aspergillus* spp.
- (C) *Bacillus* spp.
- (D) *Candida* spp.

(2013)

Answer: (A) *Pseudomonas* spp.

Explanation: The primary spoilage of refrigerated poultry, along with other fresh meats stored at **low temperatures** (below 4°C), is typically caused by **psychrotrophic** bacteria, with ***Pseudomonas* species** being the predominant group. These bacteria thrive in cold conditions and utilize simple nutrients on the meat surface. Their growth leads to the development of off-odors (often described as sour or fruity initially, then putrid) and the characteristic **viscous slime** or film on the meat's outer surface when the bacterial count reaches critical levels (around 10^7 to 10^8 cells per gram). Other psychrotrophs like *Acinetobacter* and *Moraxella* also contribute, but *Pseudomonas* is generally the major causative agent under aerobic, chilled storage conditions. The formation of the slime is essentially a colony of bacteria and their extracellular products.

Q.5 The weight gain (in gram) per gram protein consumed is called

- (A) Net Protein Ratio (NPR)
- (B) Biological Value (BV)
- (C) Protein Efficiency Ratio (PER)
- (D) Chemical Score (CS)

(2013)

Answer: (C) Protein Efficiency Ratio (PER)

Explanation: The **Protein Efficiency Ratio (PER)** is a nutritional measure used to assess the quality of a specific protein source. It is defined as the **gain in body weight (in grams)** of a test subject (usually a growing rat) per **gram of dietary protein consumed** over a specified feeding period. The formula for PER is: $\text{PER} = \frac{\text{Weight Gain (g)}}{\text{Protein Consumed (g)}}$. This metric is an indicator of how effectively a protein supports growth, making it particularly relevant for evaluating foods meant for children or growing animals. While other measures like Biological Value (BV) and Net Protein Ratio (NPR) also assess protein quality, PER is specifically characterized by the ratio of weight gain to protein consumed.

Q.6 Which of the following carbohydrates is NOT classified as dietary fibre?

- (A) Agar
- (B) Pectin

- (C) Sodium alginate
(D) Tapioca starch

(2013)

Answer: (D) Tapioca starch

Explanation: *Dietary fiber* is defined as the indigestible portion of food derived from plants, primarily consisting of carbohydrates that are not broken down by human digestive enzymes. The options Agar, Pectin, and Sodium alginate are all examples of **non-starch polysaccharides** that are universally recognized as components of dietary fiber. **Agar** and **Sodium alginate** are derived from seaweed, while **Pectin** is a common structural component of fruit cell walls. **Tapioca starch**, however, is a common digestible carbohydrate, a source of glucose, and is readily hydrolyzed into smaller sugars by enzymes like amylase in the small intestine. Although **resistant starch** (a form of starch that resists digestion) can be classified as dietary fiber, native tapioca starch itself is a highly digestible carbohydrate and is therefore not considered a fiber source.

Q.7 In the extruder barrel, the compression is achieved by back pressure created by the die and by

- (A) increasing pitch and decreasing diameter of the screw
(B) using the tapered barrel with constant pitch
(C) increase in the clearance between barrel surface and screw
(D) opening of the die

(2013)

Answer: (A) increasing pitch and decreasing diameter of the screw

Explanation: In a **screw extruder**, especially the single-screw type used in food processing, the material is conveyed, mixed, heated, and compressed as it moves from the feed section towards the discharge end (the die). The **compression**—which is crucial for achieving the high pressure and shear needed for cooking and shaping—is achieved through a combination of two main factors: the **back pressure** exerted by the restriction of the **die**, and the **decreasing volume** available for the material along the screw channel. This reduction in volume is mechanically engineered into the screw design by **decreasing the screw pitch** (the distance between adjacent flights) and/or **increasing the root diameter of the screw** (the diameter of the core), both of which reduce the depth of the flight channel. The correct physical principle for compression involves a reduction in the free volume to force the material forward, not an increase in pitch and decrease in diameter, as those might counter the compression effect.

Q.8 The brown colour of bread crust during baking is due to Maillard reaction between

- (A) aldehyde groups of sugars and amino groups of proteins
(B) aldehyde groups of sugars and vitamins
(C) aldehyde groups of sugars and salt
(D) starch and yeast

(2013)

Answer: (A) aldehyde groups of sugars and amino groups of proteins

Explanation: The characteristic **brown color** and complex flavor compounds developed on the crust of bread during baking are primarily the result of the **Maillard reaction**. This is a non-enzymatic browning reaction that requires heat and occurs between the **carbonyl group** (specifically the **aldehyde** or **ketone** group) of a **reducing sugar** (like glucose or maltose, which are formed from starch breakdown) and the **free amino group** of an **amino acid** or **protein** (such as those in flour and yeast). This complex cascade of reactions initially forms Amadori or Heyns rearrangement products, which subsequently decompose and polymerize into a vast array of compounds, including flavorful volatile molecules and the dark-colored polymers called **melanoidins**, which are responsible for the desirable crust color. This is distinct from caramelization, which only involves sugars.

Q.9 Blanching influences vegetable tissues in terms of

- (A) enzymes production
(B) alteration of cytoplasmic membrane
(C) stabilization of cytoplasmic proteins
(D) stabilization of nuclear proteins

(2013)

Answer: (B) alteration of cytoplasmic membrane

Explanation: **Blanching** is a mild heat treatment (typically using hot water or steam for a short time) applied to vegetables and fruits, mainly before freezing, canning, or drying. Its primary purpose is the **inactivation of enzymes**, such as peroxidases and polyphenol oxidases, which can cause undesirable color, flavor, and textural changes during storage. A crucial effect of this heat treatment, however, is the **alteration or disruption of the integrity of the cytoplasmic membrane** of the plant cells. This membrane damage increases the cell's **permeability**, allowing intracellular substances to leach out and facilitating more rapid water transport and gas exchange, which is why blanched vegetables soften and wilt. Therefore, the heat impacts the membrane's structure, which subsequently affects texture and nutrient retention properties.

Q.10 When garlic is cut or processed, the crushed garlic odour is due to the formation of

- (A) diacetyl
(B) diallyl disulfide
(C) ethyl butyrate
(D) benzaldehyde

(2013)

Answer: (B) diallyl disulfide

Explanation: The potent and characteristic odor and flavor of **crushed garlic** are due to the rapid enzymatic formation of volatile sulfur compounds. The primary odorless precursor in intact garlic cloves is the amino acid derivative **alliin**. When the garlic tissue is physically damaged (cut, crushed, or chewed), the vacuolar enzyme **alliinase** is released, which catalyzes the hydrolysis of **alliin** to form

highly reactive molecules like **allicin** (diallyl thiosulfinate). Allicin is unstable and quickly decomposes into a variety of other sulfur compounds, with **diallyl disulfide** and other poly-sulfides (like diallyl sulfide) being the most abundant and potent contributors to the final, pungent aroma profile.

Q.11 Match the toxicants of plant foods in Group I with their main plant source given in Group II.

Group I	Group II
P) Gossypol	1) <u>Khesari</u> Dahl (<i>Lathyrus sativus</i>)
Q) Vicine	2) Cotton seeds
R) Glucosinolates	3) Fava beans
S) BOAA (beta-N- Oxalyl Amino L-Alanine)	4) Rapeseeds

- (A) P-2, Q-3, R-4, S-1
(B) P-2, Q-4, R-3, S-1
(C) P-3, Q-1, R-2, S-4
(D) P-4, Q-3, R-1, S-2

(2013)

Answer: (A) P-2, Q-3, R-4, S-1

Explanation: This question requires matching specific plant toxicants with their primary botanical sources. **Gossypol (P)** is a toxic yellowish polyphenolic pigment found primarily in **cotton seeds (2)**, used in oil production, and can cause male sterility. **Vicine (Q)** is a glycoside found in **fava beans (3)** (*Vicia faba*) and is the compound responsible for the blood disorder known as favism in genetically susceptible individuals. **Glucosinolates (R)** are sulfur-containing compounds characteristic of the Brassicaceae family, notably high in **rapeseeds (4)** (canola); their breakdown products can interfere with thyroid function. Finally, **BOAA (beta-N-Oxalyl Amino L-Alanine) (S)** is a neurotoxin found in **Khesari Dahl (1)** (*Lathyrus sativus*), which is responsible for the paralytic disease called lathyrism. The correct pairing is P-2, Q-3, R-4, and S-1.

Q.12 Match the products in Group I with the enzymes used for their preparation given in Group II.

Group I	Group II
P) Aspartame	1) Lipase
Q) Cocoa butter substitute	2) Glucose isomerase
R) High fructose corn syrup	3) <u>Thermolysin</u>
S) Lactose free milk	4) Invertase
	5) Beta galactosidase

- (A) P-2, Q-1, R-4, S-3
(B) P-3, Q-1, R-2, S-5
(C) P-1, Q-3, R-2, S-4
(D) P-1, Q-2, R-4, S-5

(2013)

Answer: (B) P-3, Q-1, R-2, S-5

Explanation: This question links industrial food products with the specific enzymes crucial for their manufacture. **Aspartame (P)**, an artificial sweetener, is often synthesized using the enzyme **Thermolysin (3)**, which catalyzes the formation of the peptide bond between the two amino acid precursors (aspartic acid and

phenylalanine methyl ester). The production of **Cocoa butter substitute (Q)** often involves **Lipase (1)**-catalyzed **interesterification**, a process that modifies the fatty acid profile of a cheaper fat to mimic the thermal properties of cocoa butter. **High Fructose Corn Syrup (HFCS) (R)** is produced by converting glucose to fructose using the enzyme **Glucose isomerase (2)**. Finally, **Lactose free milk (S)** is made by hydrolyzing the disaccharide lactose into its sweeter and more digestible monosaccharide components, glucose and galactose, using the enzyme **Beta-galactosidase (5)**, also known as lactase.

Q.13 Match the food items in Group I with the type of colloidal dispersion given in Group II.

Group I	Group II
P) Mayonnaise	1) Sol
Q) Tomato ketchup	2) Emulsion
R) Cake	3) Gel
S) Curd	4) Solid foam

- (A) P-4, Q-1, R-2, S-3
(B) P-3, Q-1, R-2, S-5
(C) P-2, Q-3, R-4, S-5
(D) P-2, Q-1, R-4, S-3

(2013)

Answer: (D) P-2, Q-1, R-4, S-3

Explanation: This question tests the classification of common food structures based on their colloidal state (a two-phase system). **Mayonnaise (P)** is a stable dispersion of oil (discontinuous phase) in water (continuous phase), stabilized by an emulsifier (egg yolk), making it an **Emulsion (2)**. **Tomato ketchup (Q)** is characterized as a suspension of solid particles (pulp) in a liquid matrix, which, while complex, can be broadly classified as a **Sol (1)**, particularly when considered as a fluid suspension of small particles. **Cake (R)**, with its stable, airy structure, is formed by gas (air) dispersed and trapped within a solid matrix, classifying it as a **Solid foam (4)**. **Curd (S)**, or yogurt, is formed by the acid-induced aggregation and network formation of milk proteins (casein) which entrap water, giving it a solid, jiggly texture characteristic of a **Gel (3)**.

Q.14 [a] Assertion: In the presence of sucrose, the temperature and time for gelatinization of starch increases.

[r] Reason: Sucrose, due to its hygroscopic nature, competes with starch for water needed for gelatinization.

- (A) Both [a] and [r] are true and [r] is the correct reason for [a]
(B) Both [a] and [r] are true but [r] is not the correct reason for [a]
(C) Both [a] and [r] are false
(D) [a] is true but [r] is false

(2013)

Answer: (A) Both [a] and [r] are true and [r] is the correct reason for [a]

Explanation: The Assertion [a] is true: the addition of high concentrations of sugar, like sucrose, to a starch-water mixture significantly **raises the gelatinization temperature** and can lengthen the required cooking time. The Reason [r] is also true: sucrose is **highly hygroscopic**, meaning it has a strong affinity for water. In a starch system, water is the crucial medium that must be absorbed by the starch granules for them to swell and gelatinize. By competing with the starch granules for the available water, sucrose effectively **reduces the free water activity**. This reduced water availability means that more thermal energy (a higher temperature) is required to overcome the starch-sucrose competition and allow the starch granules to absorb enough water to begin the swelling and structural collapse associated with gelatinization, thus confirming that the Reason is the **correct explanation** for the Assertion.

Q.15 Thermal death of viable spores of *Bacillus subtilis* in a food sample follows a first order kinetics with a specific death rate constant of 0.23 min^{-1} at 100°C . The time (in minutes) required to kill 99% of spores in the food sample at 100°C will be

- (A) 10
- (B) 20
- (C) 23
- (D) 60

(2013)

Answer: (B) 20

Explanation: The thermal death of microorganisms follows **first-order kinetics**, which can be described by the integrated rate law: Where is the initial spore concentration, is the concentration after time , and is the specific death rate constant. We are given and are asked for the time required to kill of the spores. This means is of , or . Substituting this into the equation: Since The time required is approximately **20 minutes**, demonstrating the application of first-order kinetics to calculate sterilization time based on the death rate constant.

Q.16 How much skim milk (in kg) containing 0.1% fat should be added to 500 kg of cream containing 50% fat to produce standardized cream containing 36% fat?

- (A) 140
- (B) 165
- (C) 195
- (D) 210

(2013)

Answer: (C) 195

Explanation: This problem can be solved using the **Pearson Square method** or by setting up a mass balance equation. Let be the mass of cream , its fat content , be the mass of skim milk to be added, its fat content , and be the desired final fat content . The total mass of fat is conserved: Substitute the given values (using decimal fractions

for percentages): Rearranging the terms to solve for : Therefore, approximately of skim milk must be added to standardize the cream.

Q.17 Which of the following statements is NOT CORRECT in relation to muscle proteins?

- (A) Actin and myosin interact to form actomyosin which is responsible for muscle contraction
- (B) Collagen contributes to the toughness of muscles due to its abundant presence
- (C) Elastin, a constituent of ligaments, is tougher than collagen
- (D) Actomyosin is not the main state of actin and myosin in post-mortem muscles

(2013)

Answer: (C) Elastin, a constituent of ligaments, is tougher than collagen

Explanation: The statement that **elastin is tougher than collagen** is **NOT CORRECT**. **Collagen** is the most abundant protein in the body, forming strong, non-elastic fibers in connective tissue, and its high presence and cross-linking are the main reasons it **contributes significantly to the toughness of muscles** (Statement B is TRUE). **Elastin**, in contrast, is a highly **elastic** protein found in connective tissue, such as in ligaments and arterial walls, allowing them to stretch and recoil; it is **less tough and more rubber-like** than collagen (Statement C is FALSE). Statement A is TRUE because **Actin and myosin** are the primary contractile proteins that interact to form **actomyosin**, the motor of muscle contraction. Statement D is also TRUE; in the **post-mortem** muscle, the formation of **rigor mortis** is due to the permanent and rigid **actomyosin** cross-bridge, meaning the individual proteins, actin and myosin, are no longer in their readily separable state.

Q.18 A cold storage plant is used for storing 50 tonnes of apples in perforated plastic crates. During the storage, apples are cooled down from 28°C to storage temperature of 2°C . (Specific heat of the apple = $0.874 \text{ kCal kg}^{-1}^\circ\text{C}^{-1}$). If the required cooling is attained in 16 hours, the refrigeration plant capacity (in Tons) is

- (A) 19
- (B) 24
- (C) 29
- (D) 32

(2013)

Answer: (B) 24

Explanation: To calculate the refrigeration capacity, we first determine the **total heat removed** from the apples.

Mass :

Temperature difference :

Specific heat :

Heat removed :

The cooling is achieved in . The **rate of heat removal** is:

Finally, we convert this rate to **Tons of Refrigeration (TR)**. One TR is defined as the heat removal rate required to freeze of water at in , which is equivalent to approximately . Therefore, the required refrigeration plant capacity is approximately . (Note: This calculation only accounts for sensible heat; a complete answer would also include heat of respiration and heat leakage, but based on the provided data, this is the intended result.)

Michaelis-Menten equation, which describes the kinetics of many enzyme-catalyzed reactions:

We are given the following values:

- Initial velocity
- Maximum velocity
- Substrate concentration We need to solve for the Michaelis constant in molar concentration . Rearranging the equation to solve for :

Substitute the given values into the rearranged equation:

The value of the enzyme is , which represents the substrate concentration at which the reaction velocity is half of .

Q19. An actively growing culture of *Acetobacter aceti* is added to the vigorously aerated fermented fruit juice medium containing 10 g l^{-1} ethanol to produce vinegar. After some time, the ethanol concentration in the medium is 0.8 g l^{-1} and acetic acid produced is 8.4 g l^{-1} . What is the conversion efficiency of the process with respect to theoretical yield?

- (A) 30
(B) 50
(C) 70
(D) 90

(2013)

Answer: (C) 70

Explanation: The biological conversion of ethanol to acetic acid by *Acetobacter aceti* is:

First, calculate the **mass of ethanol consumed** and the **theoretical maximum yield** of acetic acid.

Ethanol Consumed: .

Molecular Weights: Ethanol ; Acetic Acid .

Theoretical Yield: The molar ratio is , so the theoretical yield is based on a mass ratio of times the ethanol consumed.

Conversion Efficiency: This is the ratio of **actual acetic acid produced** to the **theoretical yield**, expressed as a percentage.

The conversion efficiency of the process is , demonstrating that of the theoretically possible acetic acid was formed from the consumed ethanol.

Q.20 An enzyme catalyzed reaction (following Michaelis-Menten kinetics) exhibits maximum reaction velocity (V_m) of $75 \text{ nmol l}^{-1} \text{ min}^{-1}$. The enzyme at a substrate concentration of $1.0 \times 10^{-4} \text{ M}$ shows the initial reaction velocity of $60 \text{ nmol l}^{-1} \text{ min}^{-1}$. The K_m value of the enzyme in molar concentration(M) is

- (A) 2.5×10^{-5}
(B) 5.0×10^{-5}
(C) 2.5×10^{-4}
(D) 5.0×10^{-4}

(2013)

Answer: (A) 2.5×10^{-5}

Explanation: This problem requires the application of the